nature and science

Volume 4, Numbers 1 - 17

1966 - 1967

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nature and science
TEACHER'S EDITION
VOL. 4 NO. 1 / SEPTEMBER 19, 1966 / SECTION 1 OF TWO SECTIONS
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THE NATURE AND SCIENCE ROUTE TO BETTER SCIENCE TEACHING

If you're subscribing to NATURE AND SCIENCE for the first time, welcome aboard. If you're already one of the seventeen thousand teachers now using The American Museum of Natural History's new magazine, welcome back!

In the following pages you'll find a partial listing of the many new articles, reports, photographic essays, investigations, and projects NATURE AND SCIENCE has in store for you and your students during the coming year. Each issue takes up at least a half dozen different aspects of science, designed to augment and enrich the science curriculum.

Science Adventures, Science Mysteries, and other feature articles combine photos, drawings, and text to introduce your pupils to all kinds of major scientific inquiry. In the course of the school year, NATURE AND SCIENCE takes your pupils to laboratories, to field stations, and on expeditions, giving them insights into the ways that biologists, geologists, anthropologists, and many other scientists carry out their investigations. Many of these articles are written by the scientists themselves.

Each of the articles is written in a way that doesn't talk down to youngsters—yet is always lucid and easy to read. By the end of the year, you'll be surprised how much their vocabularies have expanded! Articles make excellent home reading and good subjects for special assignment. By assigning NATURE AND SCIENCE articles for reading at home or in class, the teacher not only helps young people develop their reading ability, but may instill an enduring love for learning from the printed word.

EDUCATIONAL SERVICES INCORPORATED
HARRY BEEDE

In the classroom or outside of it, the lesson that is best remembered is the one learned by direct experience.

10 WAYS TEACHERS ARE USING NATURE AND SCIENCE

1. To start children investigating natural phenomena on their own in a scientific manner.
2. To amplify and update concepts presented in texts and to spark lively and meaningful class discussions.
3. To develop children's skills in observing, formulating meaningful questions, investigating, and evaluating their findings.
4. For homework assignments and for classroom reading.
5. As a source of ideas for themes, small group investigations and reports, science club projects, science fair exhibits, weekend and vacation science projects.
6. For assignments that relate science to other subjects such as English, history, social studies, and the visual arts.
7. To stimulate interest of slow readers and for remedial reading instruction.
8. As extra educational nourishment for the fast learner.
9. As a springboard for field trips to zoos, museums, botanical gardens, a neighboring park, a nearby stream or woods.
10. As a "how to" guide for making, acquiring, and maintaining simple classroom "hardware" such as terrariums, aquariums, balances, sundials, homemade microscopes, bird feeders, etc.

Although many teachers use NATURE AND SCIENCE in conjunction with a textbook, several hundred teachers have discovered they can use NATURE AND SCIENCE as the main "text" for an informal yet effective science course throughout the year.

Science Workshops and Investigations in each issue suggest ways young people can start scientific collections, build their own equipment, and make their own firsthand observations. Most projects use simple materials that are easily available: milk cartons, window screen, straws, bottles, string, aluminum foil. The idea is to teach by example . . . by doing. By performing the investigations and workshop projects, boys and girls learn how to ask meaningful questions and seek the answers in a scientific way—abilities that are of importance and value no matter what career the student eventually decides on. The lesson that is best remembered is the one learned by direct experience. NATURE AND

SCIENCE encourages youngsters to use their spare time performing simple but enlightening investigations and experiments: making a barometer or microscope; measuring relative humidity; testing the effect of gravity on moving objects.

Brain-Boosters. Each issue of NATURE AND SCIENCE contains a page of educational puzzles, questions, and problems that challenge the imagination and reasoning power of youngsters and pose small projects that help them fill odd moments constructively. Brain-Boosters have a magnetic attraction for young readers (and often for their teachers as well).

How It Works. NATURE AND SCIENCE attempts to achieve a balance between theoretical and applied sciences. One of the magazine's frequent features is a page that "takes apart" household and everyday appliances. The air conditioner, television, speedometer, gasoline pump, fireplace are some of the objects that will be pictured and described in the coming issues to show what makes them work.

Special Topic Issues. Four times a year, NATURE AND SCIENCE devotes an entire issue to exploring a single subject in depth. This year's special topics will be Sound Waves, Diseases and Public Health, Reproduction and Embryology, and Rivers and Man.

Teacher's Edition. Certain articles in NATURE AND SCIENCE offer teaching possibilities far beyond those suggested in the articles themselves. Each issue of the Teacher's Edition presents additional background information about the subject matter, as well as suggestions for using the article in the classroom. These suggestions, including topics for class discussion and often additional activities that can be carried out by your pupils, are offered to help you guide your pupils to a deeper understanding of the scientific concepts involved, and to awaken them to some of the broader implications of those concepts.

(The Teacher's Edition accompanies your desk copy of NATURE AND SCIENCE—both are free for teachers ordering ten or more subscriptions.)

A preview of some of the articles now in progress for the 1966-67 school year.

HAY, HAY, HAY AND A BUCKET OF BLOOD It started with a few cows that died from eating spoiled hay—and today we have an amazing chemical that saves thousands of human lives. This story tells how scientists made the discovery.

MAKE YOUR OWN SEA AQUARIUM How to make and set up in the classroom or home an inexpensive "miniature ocean," and what to look for once it's stocked.

STARS AT MIDNIGHT Are the same stars "out" all night? . . . every night? By keeping track of their observations over several months, your pupils can relate the apparent motion of the stars to the earth's motion.

SCIENTISTS ON ICE High in the Olympic Mountains of Washington, scientists are probing glaciers to learn more about the "records" locked inside these rivers of ice.

HOW SPIDERS BECAME SPINNERS The ancestors of spiders didn't spin webs. Why spiders do today is a puzzle that scientists wish they could unravel.

PERPETUAL MOTION MACHINES Down through history, men have tried to build a machine that wouldn't run down. No one has ever succeeded, because such machines can't work . . . or can they?

MY YEARS WITH THE EAGLES Is the bald eagle dying out? What must be done to preserve it? A young biologist tells of his discoveries after three years of studying our national bird.

HEADS OR TAILS—A MATTER OF CHANCE If you flip a penny many, many times, how often will it come up heads? By charting results, your pupils learn a basic concept of probability.

THE HUMAN VOICE Are all voices different? What makes our voices change? How do vocal cords operate? Why do some people "lose" their voices?

THERE'S MORE THAN ONE WAY TO EAT AN EGG This remarkable series of close-up photographs shows how a snake eats an egg—shell and all!

ON THE TRACK OF MOUNTAIN LIONS A wildlife biologist tells of his adventures as he studies the stealthy habits of one of North America's biggest predators, the mountain lion.

HOW STRONG IS PAPER? Testing the strength of paper towels, wet and dry, and comparing towels of different brands, leads to an examination of how engineers test the strength of different materials.

INTO THE WORLD OF BEES AND WASPS This Science Workshop project describes a safe, simple way to make nesting sites for non-stinging wild bees and wasps, and how to study their behavior.

TESTING YOUR REACTIONS Some simple ways your pupils can test their own and their friends' reaction time, steadiness, visual acuity, etc.

FINGERPRINTS How to "take" your own fingerprints—how to classify and identify them; how "friction ridges" help you hold things; how prints are produced when you touch things.

PLUS . . . The Beginning of Farming • From the Stone Age to the Bronze Age • Colors from Plants • Grocery Shelf Racing • How Much Do Animals Eat? • Ice Cube Keepers • Trajectories • Packing Problems • Investigating Wildflowers • How Streams Flow • and many other articles designed to entertain, inform, stimulate—and make teaching easier for you!

nature and science

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Join weather scientists as the
trace the birth, growth, and
death of a ravaging storm.

see page 12

INSIDE A HURRICANE

Everyone has heard of the "big bad wolf."
To find out what wolves are really like, see page 2

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the big GOOD wolf

by Dave Mech

Fairy tales are fun, but don't count on them for the truth. Here is what biologists have learned about the real life of the wolf.

■ Once upon a time there was a girl named Little Red Riding Hood. She was almost eaten alive by a wolf dressed like her grandmother. It was a big *bad* wolf, of course, because all wolves in fairy stories are big and bad. Remember "Three Little Pigs" and "Peter and the Wolf"?

Nearly everyone knows these stories by heart, and if this is all a person knows about wolves, he can't help but view them as pretty bad characters. But a few scientists have spent years studying the wolf, and they have different ideas. They learn by observing, by doing experiments, and by carefully reading other scientists' discoveries. They don't pay much attention to fairy tales.

Many of the things that scientists have learned about the wolf and the way it lives are much more interesting than fairy stories. We know, for example, that the wolf *is* big. Most males weigh 80 to 100 pounds, and some get almost twice this size. The animals usually travel in family groups called *packs*. Although most packs contain four to eight wolves, some include as many as 20. Wolves are found only in the wilderness. In the United States (outside of Alaska) most of them live in Minnesota, although a few wolves still survive in Michigan and Wisconsin.

The wolf is a *carnivore*—an animal that eats meat. The

This timber wolf, captured by Canadian biologists, is being fitted with a special collar containing a radio. When the wolf is let go the biologists can trace its travels by pinpointing the signals sent from the radio.

wolf has no other choice. He cannot live long on grass, leaves, or other vegetable matter. Unlike humans, the wolf has no one to kill his meat for him. He must do it himself, and that is where he gets into trouble.

Wolves vs. People

People have three complaints against the wolf: (1) They think wolves are dangerous to humans. (2) They accuse wolves of killing cattle and other livestock. (3) They believe that wolves kill too many deer, moose, and other game animals that man likes to kill for himself. Each of these activities seems to work against man and his wishes, so the wolf is thought of as a villain.

The first of these charges is most serious. If wolves did go around gobbling up people, we certainly would have to do something about it. However, in North America there has never been a proven case of a healthy wild wolf attacking a human being. Of course, a wolf with the *rabies* disease, just like a fox, skunk, or dog with rabies, might bite people. Also, a half-tame wolf that has lost his fear of man couldn't be trusted. (Neither can a half-tame bear, fox, raccoon, deer, or other wild pet.) Perhaps a female wolf defending her young would attack, or possibly if someone wounded a wolf, the wolf might turn on the hunter. But if such cases exist, they are extremely rare.

Probably fairy stories had much to do with making people think wolves are dangerous. Of course, wolves *are* large enough to harm humans, and there may actually have been a time in Europe and Russia when wolves did kill a few people. There are even occasional newspaper stories about such happenings in North America. However, a friend of mine, 80-year-old Lee Smits of Detroit, Michigan, has investigated every such report he has come across. He has never found one to be true. They either are rumors, false reports, or only partly true stories.

In a way, I myself am living proof that wolves don't include humans in their diet. While studying a pack of 15 wolves for three winters in Isle Royale National Park (in Lake Superior), I often chased them away from their supper. This is something you shouldn't even do to your pet dog! But the wolves were so afraid of me that they usually ran when I was 500 feet away.

". . . Bounding Straight Toward Me"

I shall never forget the first time I broke up the wolves'

(Continued on the next page)

The author, Dr. L. David Mech (left) examines the carcass of a moose killed by wolves in Isle Royale National Park. Bush pilot Don Murray is on the right. By looking at many such carcasses, Dr. Mech learned that the wolves seldom killed a strong, healthy moose.

The Big Good Wolf (continued)

dinner party. My bush pilot Don Murray and I in our light skiplane had followed the 15 wolves all day. We watched them chase a cow moose and twin calves. As soon as they killed one of the 300-pound calves, we landed on the nearest frozen lake. It took me half an hour to snowshoe to the kill. When I got to within 150 yards, most of the wolves scrambled off. But a few stayed until I was within 75 feet; then they fled. The hungry pack howled mournfully as I began to examine the partly eaten moose.

Meanwhile, the pilot circled above, keeping a close eye on the wolves. Don had half-jokingly told me he would dive at any wolves that returned to the kill while I was there. He wasn't so sure they wouldn't attack me. Actually I wasn't too sure either!

Suddenly I heard the plane roar as it dived toward me! Could the pack be coming back? I looked up just in time to see two huge gray wolves bounding straight toward me. A few more leaps and they could be on me. Many things flashed through my mind. I had a movie camera in one hand; should I try to get some pictures? After all, there had never been a proven case. . . . Or should I draw my revolver?

I drew my gun—faster than any TV star had ever done. But I never needed to shoot. As soon as the wolves saw me move, they skidded to a halt, turned tail, and fled more quickly than they had come. Of course, it wasn't because they saw the gun. I think they just couldn't smell me through all the odor of the freshly killed moose, so they thought I was gone. Only when they saw me move did they realize I was still there. Boy, were they surprised! This showed me more than ever that wolves are extremely afraid of man.

Killing To Live

Another reason people think wolves are bad is because they believe that these carnivores kill sheep, cattle, and other livestock. There is some truth to this charge. *Some* wolves do kill *some* livestock. However, most often the livestock are killed by dogs or "brush wolves" (another name for coyotes) rather than by real timber wolves. There are few timber wolves left in this country, and even these few live mostly in the deep wilderness—far from livestock.

A more serious charge against the wolf is that it kills many of the game animals that hunters want for themselves. Wolves do kill many deer, moose, caribou, and other "big game" animals. My own studies showed that the pack of 15 wolves on Isle Royale kill an average of one moose every three days. Milt Stenlund, a biologist in Minnesota, estimated that a pack of three wolves kills one deer per four days. In British Columbia, another biologist found that a pack of five or six wolves killed three elk in about two weeks.

Some deer or moose hunters get angry when they see figures like these. They think that every animal a wolf kills is one less that they can shoot. But the workings of nature are not as simple as that. For one thing, few hunters get back into the wilderness areas where wolves are found, so they are able to shoot only a small part of the big game in these areas.

Minnesota is a state whose wilderness is probably more hunted than most. Yet a study of wolves and deer there showed that hunters were killing only about 8 of every 100 deer per year. About 30 young are born each year from every 100 deer. This means that about 30 out of every 100 deer must die to keep the deer herd and its food supply in healthy balance. If hunters do not shoot enough deer, then disease, starvation, or something else will kill them. Thus it is not true that every deer a wolf kills takes one "away" from hunters.

Keeping Moose under Control

There are some places where numbers of big game would rise if it were not for the wolf. In such areas the animal numbers would rise until they ruined the food supply for many years. Then their numbers would drop. Since hunters are not able to kill enough animals in these areas,

This wolf pup was "knocked out" with a drug, then identity tags were put in its ears. If the animal is captured again, biologists can recognize it from its tags and learn something about the wolf's growth and travels.

it is a good thing that wolves help control the herds.

One area like this is Isle Royale National Park. Hunting is not allowed in this park, and before 1949 there were no wolves there. The moose herd grew and grew until many died from starvation. The moose had many diseases and the plants on which they fed were nearly ruined. Then wolves crossed the ice to the island. They now control moose numbers, and the food plants are becoming healthy again.

On Isle Royale, I discovered that the wolves kill mainly the young, old, sick, and injured moose. Of 50 wolf-killed moose I examined, not one was between a year old and six years old. Most were younger than one year or older than 10 years. Many were infested with ticks and tapeworms. Dr. Adolph Murie found similar results in his study of wolves and Dall sheep in Alaska. Other biologists who have studied wolves that hunt musk-oxen and caribou have found the same thing—wolves seldom kill a strong, healthy animal.

Another good effect of the wolf on Isle Royale is the increased number of young born to the moose herd each year. Healthy animals with a good food supply produce many young. People who raise cattle, horses, and other livestock know this and try to keep their herds healthy so the animals will produce as many young as possible. This is about what is happening on Isle Royale. Before the wolves lived on the island, the moose had very few twins. Now that wolves have trimmed down the herd, many female moose have twin calves—a clear sign of a healthy moose herd.

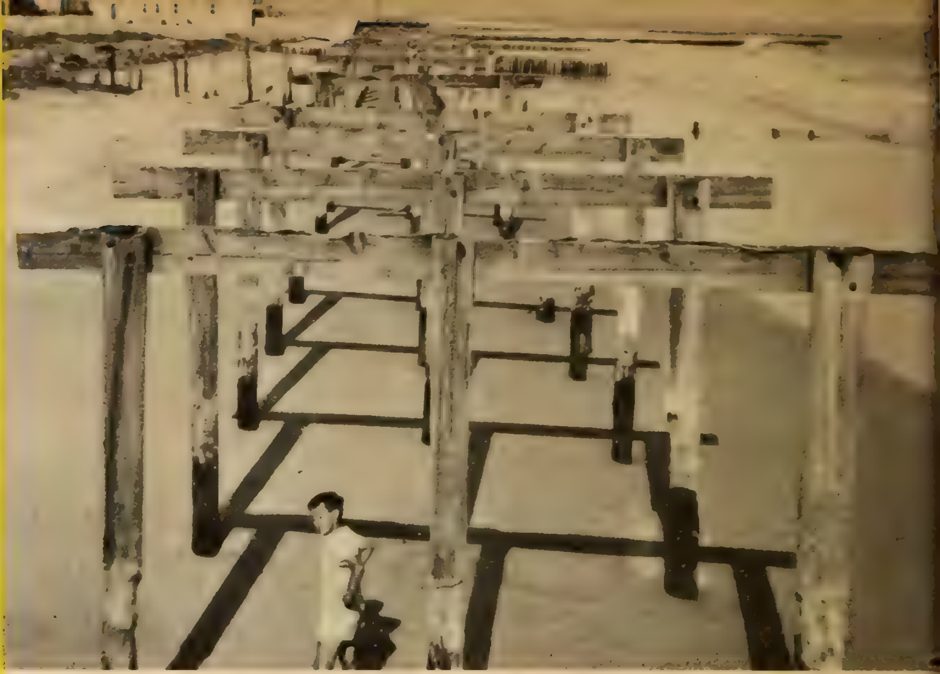
Despite all this evidence on the good effects of wolves, some people still find it hard to think of the wolf as anything but a villain. They probably just don't like the fact that the wolf kills things. But if they stopped to think, they would realize that cats kill mice, robins kill worms, and that people kill almost everything.

Wolves don't even have bad "personalities." People who have made pets of them or who have lived in the wild with half-tame wolves claim that they are very friendly, loyal, and playful. When I once saw one of the Isle Royale wolves only 15 feet away, I had the same thought. The wolf just tilted his head sideways and looked at me. He didn't look vicious or ugly, and I almost thought I could pet him. He finally just ran off without even growling. Somehow I just couldn't picture him dressing up like a grandmother and trying to eat little girls! ■

The author took this photo fron airplane as a pack of wolves tacked a moose. He found that wolves killed one moose about e three days, keeping the moose l in a healthy balance with their ply of plant food.

Brain Boosters

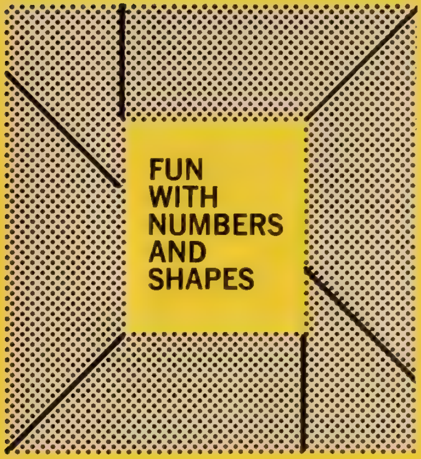
prepared by **DAVID WEBSTER**

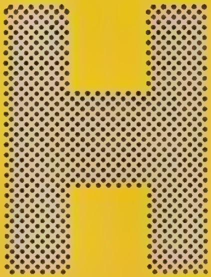


MYSTERY PHOTO

Can you tell from these shadows around lunch time whether this picture was taken in New Jersey or in California?

FUN WITH NUMBERS AND SHAPES





Cut up a rectangle as shown and throw the center piece away. Using the other six pieces, can you make a big "H" that looks like this?

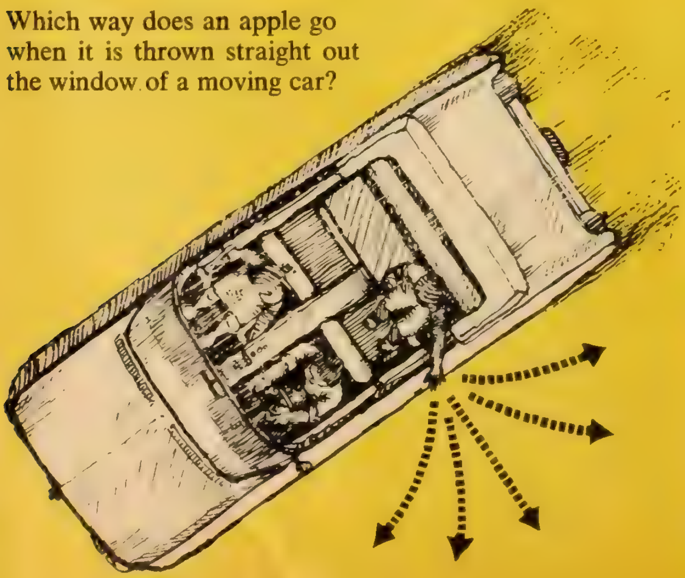
Can You Do It?

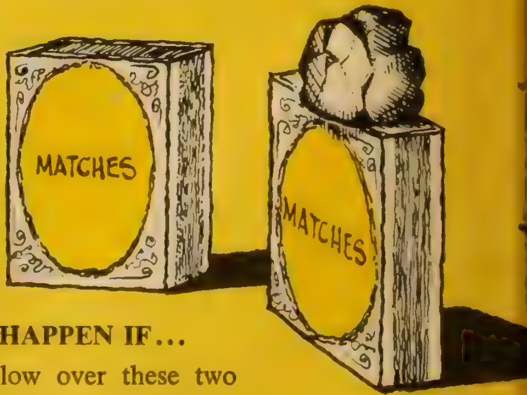
Can you get a square picture of light from a round hole?

Submitted by Chris Gately, Colorado Springs, Colo.

FOR SCIENCE EXPERTS ONLY

Which way does an apple go when it is thrown straight out the window of a moving car?





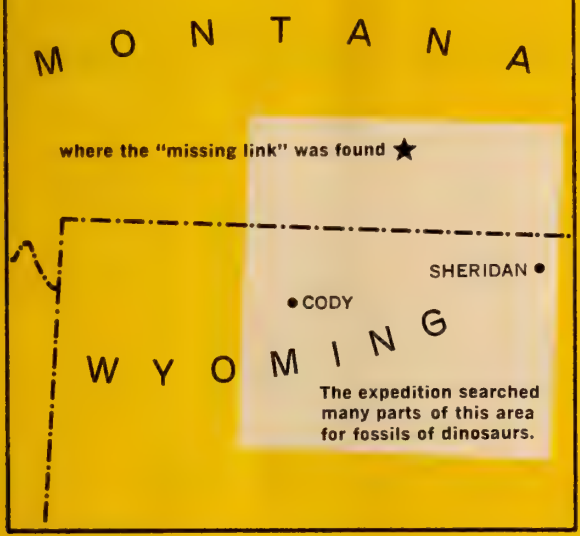
WHAT WOULD HAPPEN IF...

...you tried to blow over these two match boxes? Which one could you blow down easier?

HAVE YOU AN IDEA FOR A BRAIN-BOOSTER?

Send it with the solution to David Webster, R.F.D. #2, Lincoln, Massachusetts. If we print it, we will pay you $5. Be sure to send your name and address. If several readers submit the same idea, the one that is most clearly presented will be selected. Ideas will not be returned or acknowledged.

ON THE TRACK OF DINOSAURS


MONTANA
where the "missing link" was found ★
SHERIDAN
CODY
WYOMING
The expedition searched many parts of this area for fossils of dinosaurs.

■ For the past five summers, scientists from Yale University have hiked over 2,000 miles across the rugged lands of Wyoming and Montana, searching for remains of dinosaurs. Their chances of finding many fossils were not good. The rocks in the area were forming about 116 million years ago—a time when much of North America was covered with shallow seas. There was little dry land on which dinosaurs could live, so fossils of dinosaurs are scarce. These fossils are especially valuable, however, because so little is known about the dinosaurs that lived then.

The "dinosaur hunt" paid off. The scientists were led by Dr. John H. Ostrom, Assistant Curator of Vertebrate Paleontology at Yale's Peabody Museum of Natural History. They roamed from the Crow Indian reservation in Montana to the southern part of the Big Horn Basin in Wyoming *(see map)*. They found the fossils of several small dinosaurs, but the most exciting discovery was made in the summer of 1965, when a 25-foot-long dinosaur was dug up. Its skeleton was complete except for parts of its tail and one leg. From a look at the dinosaur's teeth, Dr. Ostrom could see that the animal ate plants. Its sturdy hind legs and heavy tail are clues that the dinosaur stood mostly on its hind legs, perhaps like a kangaroo.

"We can learn a lot about this kind of dinosaur from its skeleton," says Dr. Ostrom, "but we have to keep in mind that this is just a single specimen. We cannot assume that all individuals of this species were exactly like this one, any more than we could say that *one* 10-year-old boy is typical of *all* boys that age."

The dinosaur's bones were taken to Yale University, in New Haven, Connecticut, where they are now being cleaned and studied *(see photo)*. All scientists who study dinosaurs will be interested in Dr. Ostrom's findings, because the newly-discovered dinosaur is a "missing link" in the family tree of these ancient reptiles.

One of the earliest dinosaurs in North America was *Camptosaurus*—a 5- to 8-foot-long plant eater that lived about 136 million years ago. *Camptosaurus* has always been thought to be an ancestor of the big duck-billed dinosaurs that lived about 86 million years ago. "This new find," says Dr. Ostrom, "is clearly between *Camptosaurus* and the duck-bills."

Dr. Ostrom also believes that this "new" dinosaur is very much like *Iguanodon*—a European dinosaur that lived at about the same time. After more study of the "missing link," Dr. Ostrom plans to visit Europe to compare his find with the dinosaurs discovered there.

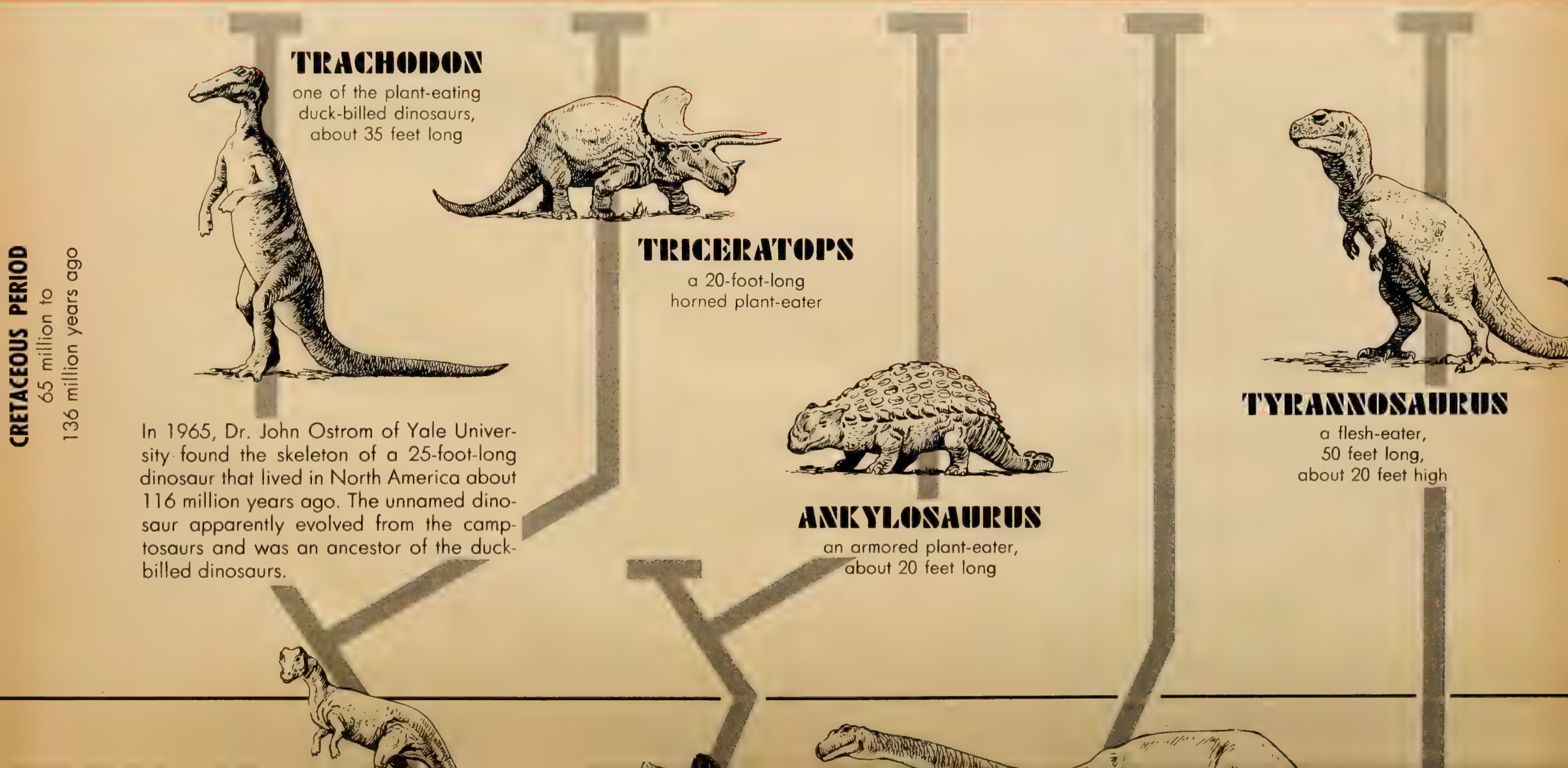
Even though the dinosaurs died out 65 million years ago, the story of how they evolved is still being pieced together. To find out what is known about the family tree of dinosaurs, see the next page ■

Dr. John Ostrom (left) watches as Peter Parks of the Peabody Museum of Natural History chips bits of rock from the skull of the 25-foot-long dinosaur found in Montana.

100 million years of DINOSAURS

■ The dinosaurs ruled the earth for 100 million years—100 times as long as the history of man. During those 100 million years, many kinds of dinosaurs developed, lived for a time, and then died out. Finally, about 65 million years ago, the last of the dinosaurs died.

We may never know just how many different kinds of dinosaurs there were, or how one kind developed (evolved) from another. But scientists have pieced together a "family tree" for some of the dinosaurs that once roamed North America. You can trace the evolution of these dinosaurs by beginning at the bottom of the chart. There you will also see where the dinosaurs fit in the time scale of life on the earth. A line that ends with a crossbar (T) marks the time when a particular group of dinosaurs died out ■



CRETACEOUS PERIOD
65 million to
136 million years ago

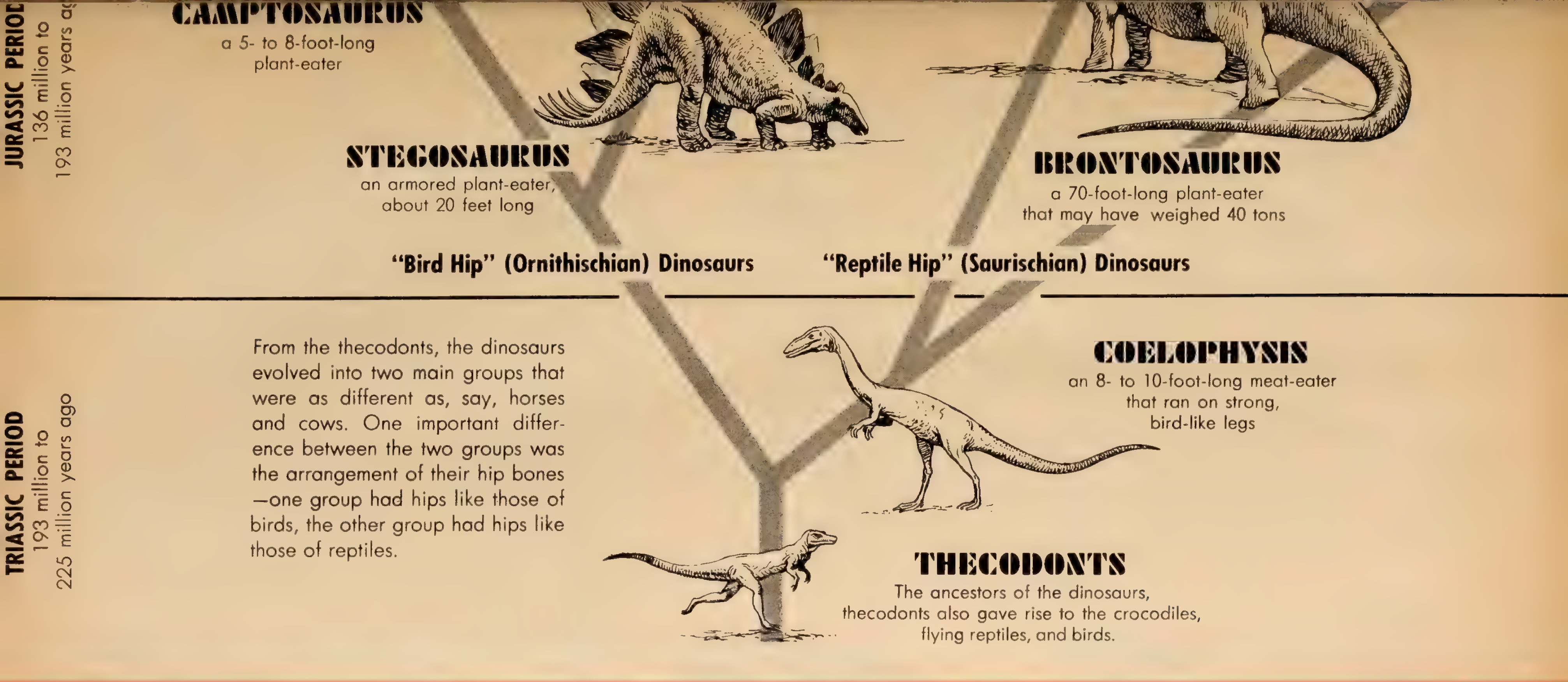
TRACHODON
one of the plant-eating
duck-billed dinosaurs,
about 35 feet long

TRICERATOPS
a 20-foot-long
horned plant-eater

ANKYLOSAURUS
an armored plant-eater,
about 20 feet long

TYRANNOSAURUS
a flesh-eater,
50 feet long,
about 20 feet high

In 1965, Dr. John Ostrom of Yale University found the skeleton of a 25-foot-long dinosaur that lived in North America about 116 million years ago. The unnamed dinosaur apparently evolved from the camptosaurs and was an ancestor of the duck-billed dinosaurs.



JURASSIC PERIOD
136 million to
193 million years ag

CAMPTOSAURUS
a 5- to 8-foot-long
plant-eater

STEGOSAURUS
an armored plant-eater,
about 20 feet long

BRONTOSAURUS
a 70-foot-long plant-eater
that may have weighed 40 tons

"Bird Hip" (Ornithischian) Dinosaurs

"Reptile Hip" (Saurischian) Dinosaurs

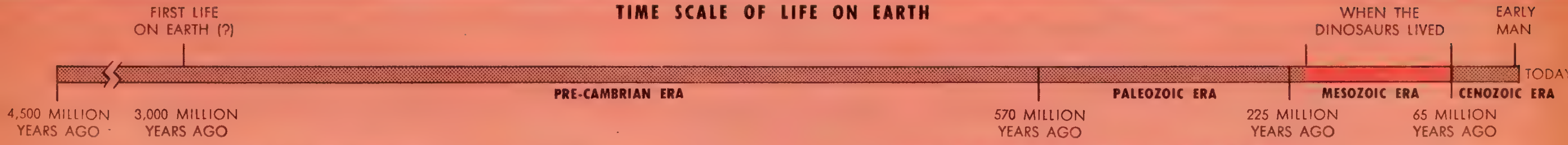
TRIASSIC PERIOD
193 million to
225 million years ago

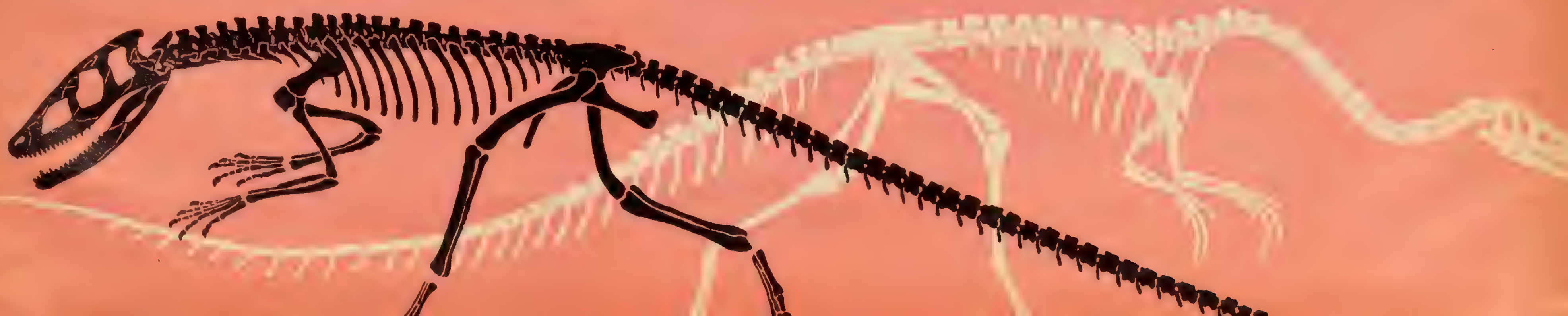
From the thecodonts, the dinosaurs evolved into two main groups that were as different as, say, horses and cows. One important difference between the two groups was the arrangement of their hip bones—one group had hips like those of birds, the other group had hips like those of reptiles.

COELOPHYSIS
an 8- to 10-foot-long meat-eater
that ran on strong,
bird-like legs

THECODONTS
The ancestors of the dinosaurs,
thecodonts also gave rise to the crocodiles,
flying reptiles, and birds.

TIME SCALE OF LIFE ON EARTH





Quick Counting

by Lynn Sagan

Here are some fast ways to find out how many peas, beans, or other particles are in a jar. Can you think of other ways?

■ How many people can be seated in your school auditorium, or in your neighborhood baseball stadium? How many grains of sand are there in the top inch of sand at your favorite beach?

It would take only a few minutes to count the number of seats in your school auditorium, but if New York's Yankee Stadium were in your neighborhood, it would take you a bit longer. You wouldn't live long enough to count the sand grains on a beach one by one, even if you counted day and night, without rest, for your entire life. Yet it is possible to *estimate*, or figure out pretty accurately, the number of sand grains on a beach, the number of stars in a galaxy, and many other things which we cannot count directly.

How To Become an Estimator

You will need four or five pint-size or quart-size glass jars or clear plastic containers. Fill each jar with "countables"—things that can be counted. You might fill one jar with Cheerios, another with marbles, another with rice, and so on. These are all "countables." The "countables" you choose should not be larger than ping-pong balls; and at least one "countable" should be something made up of very small particles, such as salt.

When you have filled each jar, guess how many "countables" are in each jar, but don't take too much time. After you guess a number for each jar, fill in the chart below.

After you have written your guess on the chart, try to find out how many "countables" there are in each jar. Use any way you can think of. Here are four ways of counting the peas that fill a jar. They were thought up by young people who were given the problem in school. Can you think of more ways?

1. You could count the peas one by one. This might seem to be the best way, or at least the most accurate way. Try it. You'll probably lose count, drop the peas all over the floor, or just give up because it stops being fun.

2. You could use one small paper cup or pill bottle, and one large paper cup. First, count the number of peas that fit in the small cup. Next, count the number of small cupfuls of peas that fill the large cup. Next, count the number of large cupfuls of peas that fill the jar. To find out how many peas there are in the jar, multiply the three numbers. For example—

25 peas fit into the small cup
5 small cups fill one large cup
8 large cups fill the jar
25 × 5 × 8 = 1,000 (peas)

3. You will need a *square* baking pan, or you could use the big squares marked on a kitchen or playroom tile floor.

OBJECT IN JAR	NUMBER GUESSED
Marbles	
Salt	
Rice	
Peas	
Cheerios	

This article is based on "Peas and Particles," a unit developed by the Elementary Science Study of Educational Services Incorporated.

A baking pan is better, because the peas won't roll around. Pour peas out of the jar and into the pan until you have a snugly packed layer *one pea deep*. Now count the peas along one side of the pan and "square" the number–that is, multiply the number by itself. (The "square" of 20 is 20 × 20 = 400.)

If you think you have some error, count the number of peas along two sides of the pan that meet, and multiply these numbers. (Are the number of peas on both sides the same? Are they pretty close?)

Empty the pan into another container, then pour a new layer of peas into it from the jar and count them the same way. Keep doing this until you have emptied the jar, then add all the numbers. The last group of peas probably won't fill the pan. If it doesn't, count the left-over peas one-by-one and add that number to your total.

Try multiplying the number of peas in the first layer that you counted by the number of layers you poured out, then add the number of left-overs. Do you get about the same number as when you counted the number in each layer you poured then added them together? Which count do you think is more accurate?

4. You can use a balance, a letter-weighing scale, or a scale used for weighing infants. First weigh the jar of peas, then pour out the peas and weigh the jar alone. Subtract the weight of the jar from the weight of the jar full of peas. This gives you the *net weight* of the peas (the weight of the peas alone). Get an *average weight* of one pea. You can do this by weighing 10 peas. Be sure to pick big ones and little ones. Divide the weight of the 10 peas by 10, and you will have the average weight of one pea. Divide the weight of one pea into the net weight of all of the peas to get the total number of peas in the jar.

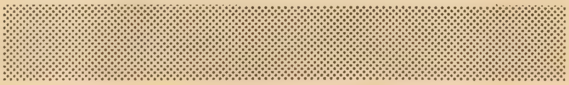
How Good Was Your Guess?

By using one or another of the four ways just mentioned you can estimate the number of "countables" in each of your jars. Write down your answers and compare them with the guesses you made. Were your guesses close? How close?

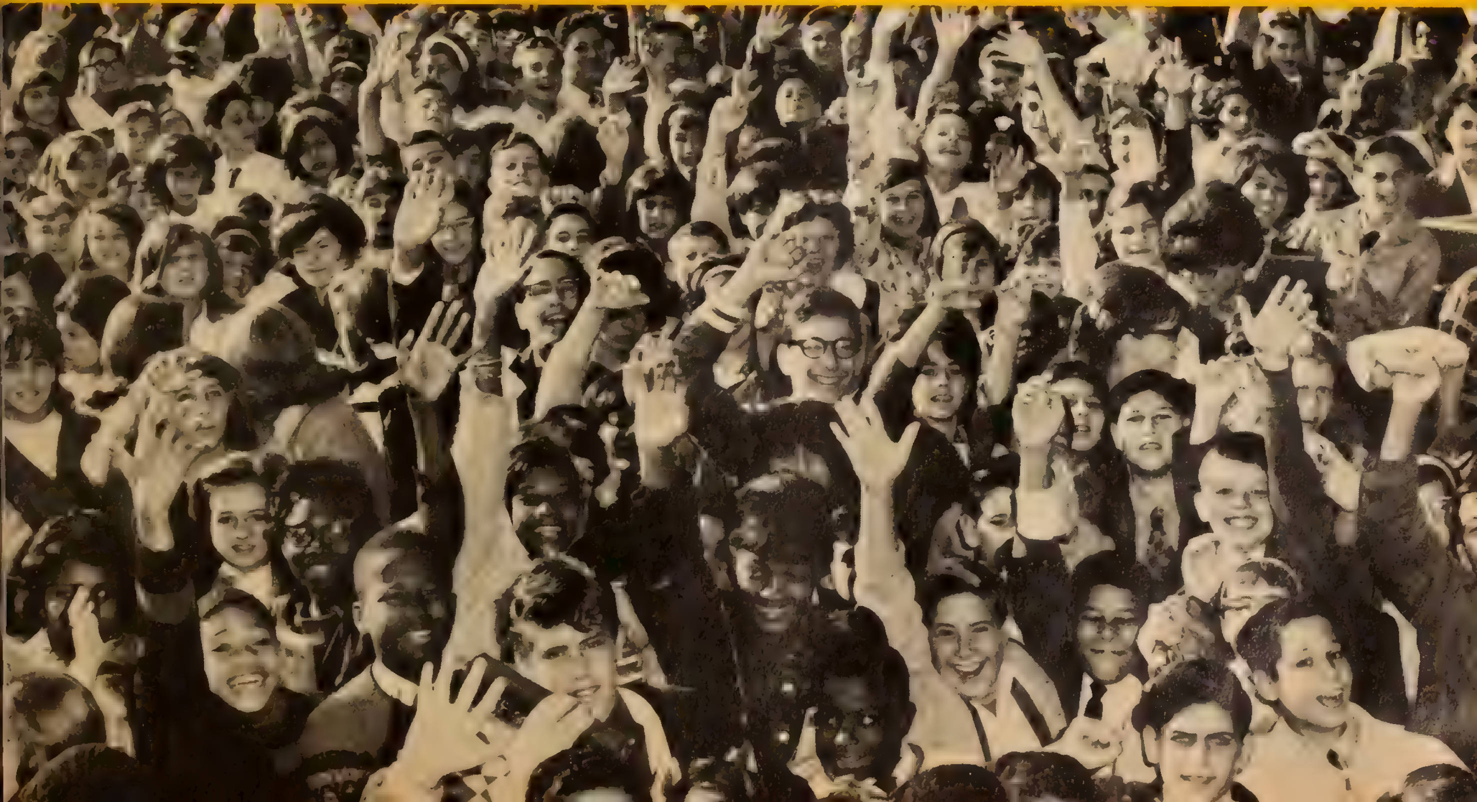
Of the four ways of estimating the "countables," which way do you think is the most accurate? Why? Which way do you think is the fastest? The slowest? Is the slowest way the most accurate? Do you now have some idea of how you could estimate the number of sand grains in the top inch of sand on a beach? ■

CAN YOU ESTIMATE

...how many fifth graders there are in your school?
...how many books there are in your school library?
...how many automobiles there are in your city?
...how many letters there are on this page?
...how many dots there are in this strip of gray? (Look at the gray strip through a magnifying glass.)



Can you figure out a way to guess about how many children are shown in this photo—without counting them one by one?



INSIDE A HURRICANE

by Gerald L. Shak

How these destructive storms are born and die, and how weather scientists are trying to "tame" them.

■ It's a blistering hot day in August. For months the summer sun has been beating down on the surface water of the southern part of the North Atlantic, heating it and setting the stage for the hurricane. The hurricane "season" begins around June, but August, September, and October are the months when most of these storms occur.

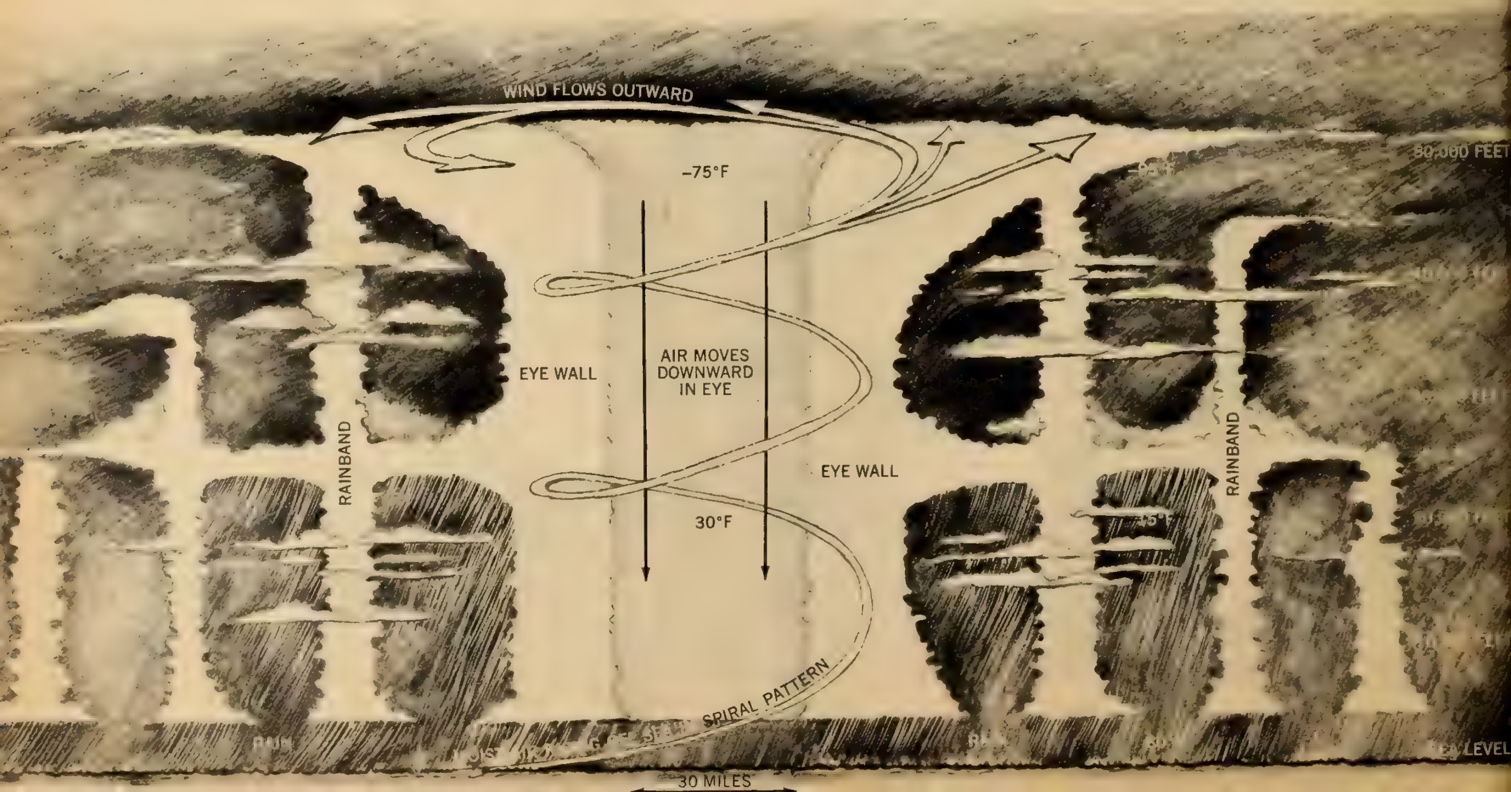
Meteorologists at the United States Weather Bureau's National Hurricane Center in Miami, Florida, have been watching weather reports from a section of ocean about 800 miles east of Cuba. Experience has taught them that this is a rich breeding ground for hurricanes.

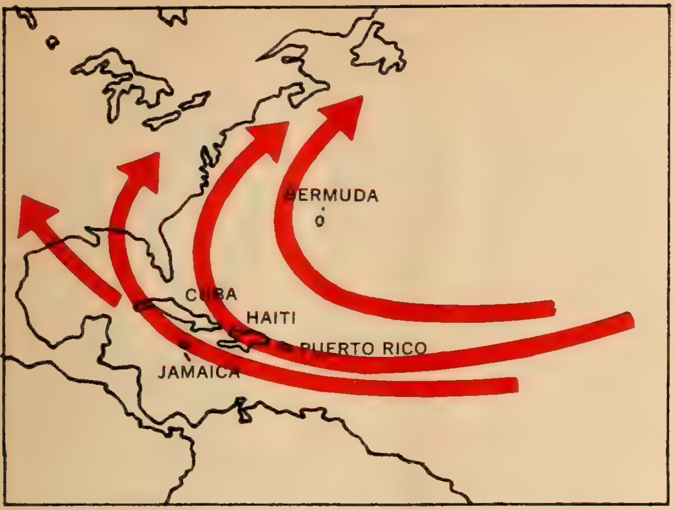
Ships in the area are reporting wind speeds much higher than those of the usually gentle easterly trade winds, and the temperature of the surface water is about 80°F. For weeks the warm surface water has been feeding moisture into the air, and moisture is the fuel of hurricanes. These facts make the Hurricane Center weather scientists suspect that a wave of air has formed in the easterly trade winds. Such a wave sometimes causes the warm air of the trade winds to pile up and rise as high as 40,000 feet or more.

Birth of the Storm

Navy aircraft are alerted to investigate the area. As a weather plane approaches it, the crew watches the clear skies become cloudy and reports towering cumulonimbus (thunderstorm) clouds. Wind speeds of 30 miles per hour at 10,000 feet and 40 to 50 miles per hour at the surface of the sea are reported. Because the storm is newly formed and large—about 200 miles wide—weather observers in the aircraft cannot see the tell-tale circle of clouds that marks a *tropical cyclone,* or hurricane. However, when a weather satellite passing high over the area sends its routine photographs to the Hurricane Center, the circular cloud pattern shows up clearly *(see photo on the next page).*

A hurricane sliced through the middle would look something like this, but not so high. The giant clouds (light areas) are formed by warm, moist air from the sea surface that cools as it is carried upward by the swirling winds.





Here are some typical paths of hurricanes originating in the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico.

This gives meteorologists the final bit of evidence they need. The cloud pattern tells them that very moist air at the ocean surface is being pushed upward and is spilling outward at high altitudes *(see diagram)*. At the same time the entire storm system is rotating, or spinning, counterclockwise. The rotation of the earth itself causes the storm to spin. (In the Southern Hemisphere, a tropical cyclone spins in the opposite direction.)

At this stage, the meteorologists at the Hurricane Center give the storm a name, *Clara,* say. Each storm of the season is given a different girl's name – *A*lma, *B*ecky, *C*lara, *D*orothy, *E*lla, and so on. The weather scientists begin to send out information about the storm: "Tropical cyclone *Clara,* moving westward at 8 miles per hour, is expected to continue in the same direction during the next 24 hours with a gradual increase in intensity, possibly reaching hurricane force in about 18 to 24 hours."

The next morning Air Force weather aircraft fly into the storm. As they head into the storm's wall cloud surrounding the "eye," they report very heavy rains and winds stronger than 77 miles per hour. (According to weather scientists, winds greater than 74 miles per hour make the storm a hurricane.) As the aircraft batters and bounces its way through the wall cloud, it suddenly enters an area of calm—the "eye" of the storm. Here there are no winds, no rain, and the sky overhead is clear, or it may be lightly veiled with very thin clouds. The pilot flies the aircraft back and forth within the eye for a half hour or so to observe the storm from its center and report the position of the eye before battering his way through the opposite wind- and rain-torn wall. He reports the diameter of the eye to be about 20 miles.

For three days *Clara* creeps toward Cuba, all the while being watched by aircraft, satellite, and now by land-based radars. Ships have been warned to stay away from the storm area and storm alerts have been sent out to people on the Cuban mainland.

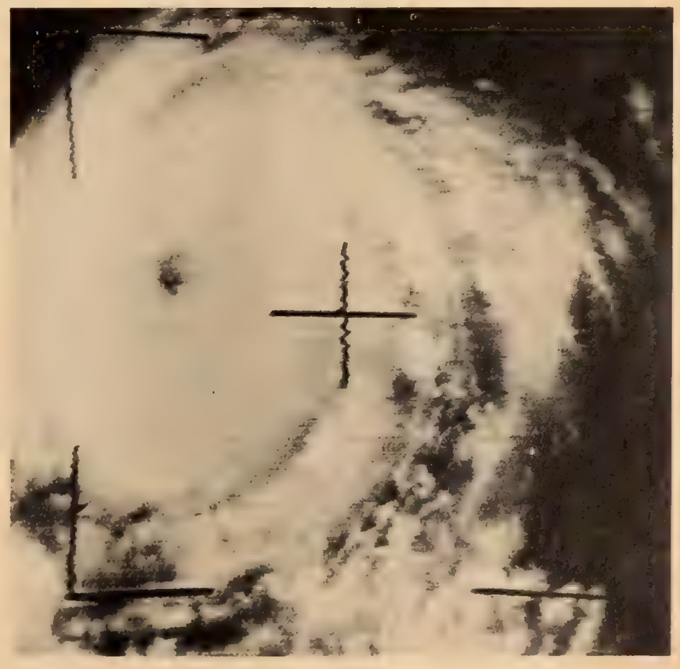
Gradually *Clara* changes direction, moving from a westerly course to a northwesterly one, and increases her forward speed to 12 miles per hour. She bypasses Cuba. By this time her torrential rains are lashing the ocean and the winds around the center reach speeds well over 100 miles per hour.

As meteorologists continue to plot Clara's course, they find that the South Carolina coast lies directly in its present path. They place the area on a *Hurricane Watch.* This is an alert given before a formal storm warning is issued. The next morning–six days after the storm was born–hurricane warnings are sent out for the U.S. coastal area from Florence, South Carolina, to Cape Hatteras, North Carolina. All along the coast the surf batters the shore.

Fury of the Storm

The winds, now blowing from a northeast direction toward the southwest, are strong enough to uproot trees and hammer houses along the beaches with waves 15 to 20 feet high. Torrential rains will soon cause streams and rivers to overflow their banks. Several hours earlier people living in the lowlands were advised to move to higher land. After an hour or more, the winds die out as the calm eye of the hurricane moves over the coast. The now still and rainless air is bathed in an eerie light as the sun peeks

(Continued on the next page)



This photo showing the top of hurricane Betsy in 1965 was taken by a Tiros weather satellite. The dark spot in the upper left part of the cloud spiral is the eye.

through the thin layer of high clouds, but the storm is only half over.

Soon the rear wall cloud of the storm approaches. The sky darkens again and the wind-driven rains return, but this time they are blowing at 100 miles per hour out of the southwest. As the hurricane moves inland, it begins to lose some of its force. The winds continue to pound the coast as the storm moves inland. Gradually they die out, the skies clear, and peace returns to the coast. But the storm itself is still very much alive; it continues moving inland, cutting a path of destruction wherever it goes. But something is happening to it.

As soon as the hurricane moved onto land it was cut off from its source of energy—warm, moist air from the sea—and gradually began to weaken. In addition, the land surface—hills, mountains, and trees—slowed down the winds. A day later, by the time the storm reaches the West Virginia hills, it has lost most of its force. Dying *Clara's* winds have now slackened to gusts of 35 miles per hour or less. The storm continues to weaken until, finally, it is overpowered by the westerly winds in the upper regions of the atmosphere, and its remaining rain clouds and moisture-laden air are carried out to sea.

Can Hurricanes Be Tamed?

Since 1956 weather scientists have been carrying out experiments—Project Stormfury—to find out if it is possible to tame these violent storms. They are trying in two ways:

1. Perhaps it is possible to make a hurricane use up its "fuel"—warm, moist air—faster than the storm can refuel, or collect moisture from the sea. Project Stormfury weather scientists are flying into hurricanes and "seeding" the eyewalls of cloud with smoke made of *silver iodide*. The smoke particles may cause the clouds to release rain faster than the clouds normally would. In this way the storm might be made to use up its fuel faster than it draws new fuel up from the ocean surface. To date, no one knows if this can be made to work.

Weather scientists also plan to see if a hurricane can be tamed by seeding the *rainband*, a narrow, curved strip of very heavy rain at some distance from the eye (*see diagram on first page of article).*

2. Another approach now being considered is to cut off the storm's supply of moisture "fuel." Perhaps it is possible to spray a local area of the sea surface with certain chemicals. The chemicals would form a blanket in front of the storm, a blanket that would keep water from evaporating off the surface as the eye of the storm passed over the sprayed area.

It is far too soon to know if either of these two approaches can be made to work. But there is only one way to find out—by trying. ■

Why do leaves fall?

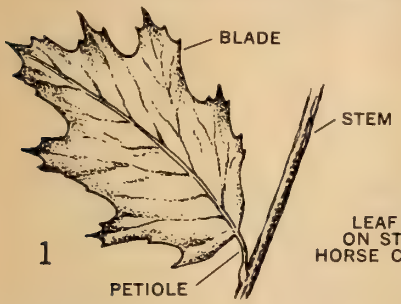
by Richard M. Klein

Soon a shower of leaves will be falling from trees. You can use some bean plants, scissors, and a pencil to find out why.

Dr. Richard M. Klein is Caspary Curator of Plant Physiology at the New York Botanical Garden.

■ As the autumn days get shorter and the nights get cooler, the leaves of many trees begin to change. Their bright green color fades and is replaced by yellows, oranges, reds, and browns. In the western mountains, the poplars turn bright yellow. In the northeastern United States, the maples, oaks, and sumacs put on a brilliant display of reds and oranges. After a few days or weeks, the leaves begin to fall from the trees.

Now, leaves don't just break away from stems at any place. If you pick up a fallen leaf, you will see that the leaf separates from the stem at the end of its narrow *petiole*. (Diagram 1 shows the two main parts of a leaf—the thin, stem-like petiole and the broad *blade*.) At the end of the petiole there is a special layer of cells called the *abscission zone*. These cells look different from the rest of the cells of the petiole. They grow differently, too.



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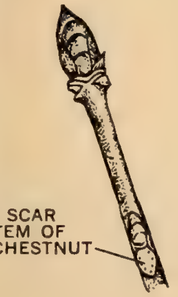


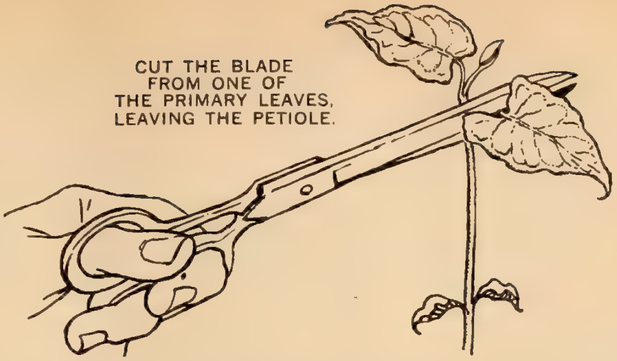
2

During the summer, the narrow abscission cells are alive and growing. In the fall, they stop growing and form a weak, corky layer. The petiole breaks away from the stem at this point. If you look closely at the stem (with a magnifying lens), you can see a leaf scar sealed over with corky cells of the abscission layer *(see Diagram 2)*.

Begin with Beans

To find *why* leaves fall from their stems, get some fresh Red Kidney Bean seeds. Soak them overnight in water and plant them in clay pots or pots made of cut-off cardboard milk cartons. (Plant about 10 seeds in each pot.) If you use cardboard cartons, don't forget to punch a drainage hole in the bottom of each. Water each pot every second or third day and be sure that they receive sunlight. If there is little sun where you are growing them, give the plants 12 to 15 hours of light from a fluorescent bulb each day.

When the plants are 10 days to two weeks old, you will see that their first leaves are large and heart-shaped. There are two of these *primary* leaves. Take a sharp, single-edged razor blade or a scissors and cut one leaf blade from each of three plants. Leave the petioles still attached to the stems. Let the other primary leaves keep growing normally. Each day, for about a week, strike all of the petioles sharply with a pencil. Keep a record of the number of days that pass before the petioles fall. Which fall first—the petioles without blades or the leaves that grew normally?


CUT THE BLADE FROM ONE OF THE PRIMARY LEAVES, LEAVING THE PETIOLE.

Now try another investigation. You will need 15 bean plants, 10 days to two weeks old. Divide them into five sets of three plants each. Treat the different sets in this way:

SET NUMBER	TREATMENT
1	cut off about ⅓ of the leaf blade
2	cut off ½ of the leaf blade
3	cut off ¾ of the leaf blade
4	cut off all but a very small piece of the leaf blade
5	cut off all of the leaf blade

Find out how many days are required for the different petioles to break from their stems. Which ones fall off first? Which ones last?

What Happens When You Mash a Leaf?

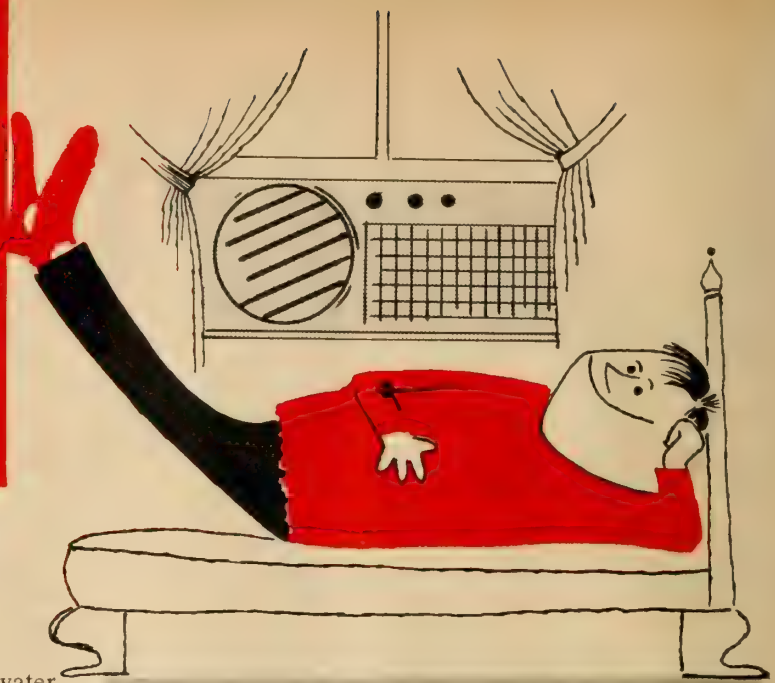
You might also try injuring some leaf blades to see how this affects leaf fall. You can put a piece of wood under a leaf and crush it with another piece of wood until it becomes sort of limp. You can also take a razor blade and make a number of cuts in the leaf blade until it is shredded (but still attached to the petiole). You can also try rubbing the leaf blade between your fingers until it becomes limp. Again, record the number of days required for the injured leaf to fall. How does this compare with healthy leaves?

Now think about your findings. What could you do to make the petioles of leaves break off the soonest? Should the blade be present or cut off? Should the blade be healthy or injured? Do you suppose that some chemical moves from the blade to the petiole and stops the corky abscission cells from forming?

You can test this idea by sharply bending the blade of a leaf or by tying a piece of thread *tightly* around the petiole just below the blade. Then compare the time of leaf fall with that of some undamaged leaves.

Now perhaps you can figure out why the leaves fall from many trees in the autumn ■

HOW IT WORKS



Air Conditioner

■ You get the "shivers" when you come out of the water at a beach or pool because your skin suddenly gets colder than it was when you were in the water. A thin film of water is left on your skin. This water is *evaporating*—changing from a liquid to a gas called water vapor. To go through this change water has to be heated. In this case, the heat comes from your skin and leaves you feeling cold.

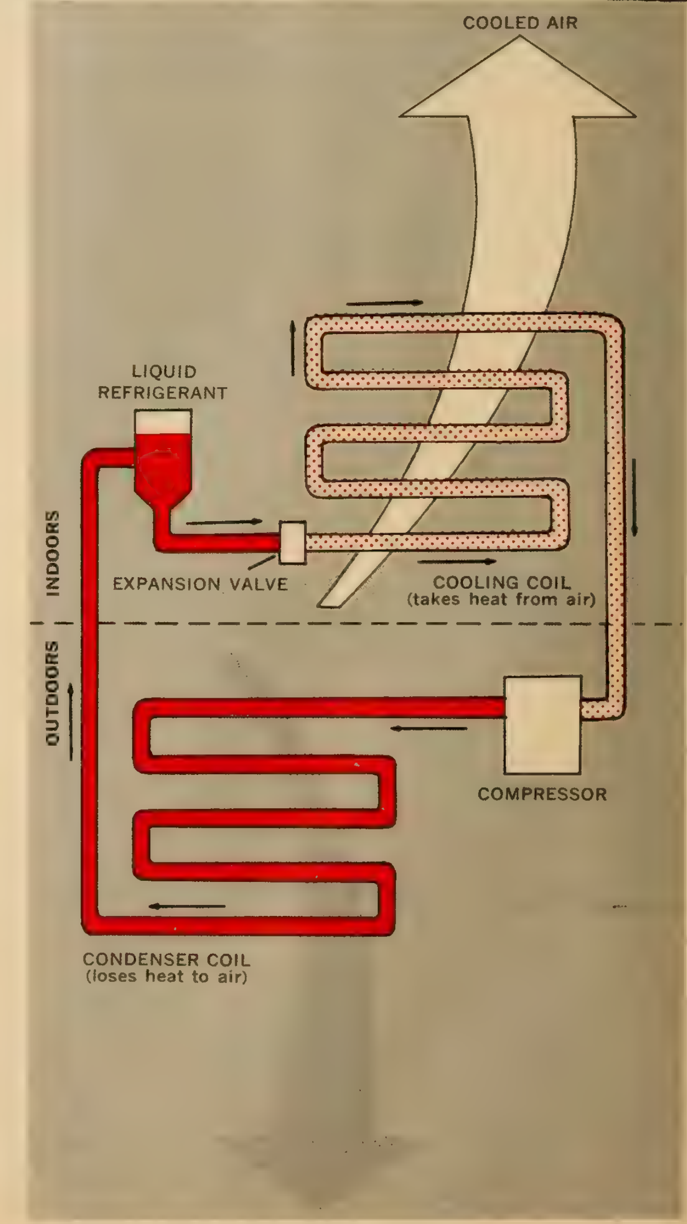
Air conditioners evaporate a liquid to cool the air in a room. A liquid *refrigerant* in the air conditioner moves from a container through a valve into the *cooling coil (see diagram)*. The valve controls the amount of refrigerant flowing into the coil.

After the liquid moves into the coil it evaporates quickly, and the gas that is formed spreads through the coil. As the liquid evaporates it takes heat from the metal forming the coil, thus cooling it. A fan draws air from the room into the conditioner, where the air loses heat to the coil. Pushed back into the room, this air picks up heat from your skin, so you feel cool.

Next, a pump removes the refrigerant gas from the cooling coil and *compresses,* or squeezes, it into a smaller space. This warms the gas. From the compressor the gas travels into a coiled tube called the *condenser coil,* which is exposed to the air outdoors. Even though the outdoor air may be 95° to 100°F, it takes heat from the coil because the compressed gas inside is hotter than the outside air. As the gas gives up some of its heat, it condenses, or turns back into a liquid. The slightly cooled liquid now flows back into the storage container.

Like a refrigerator, an air conditioner is a *heat pump,* which takes heat from one place and moves it to another.

On a hot, humid day, when the air contains a lot of water vapor, an air conditioner helps dry the air. Some of the water vapor condenses on the outside of the cooling coil and is drained off as liquid water ■



USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

The Big Good Wolf

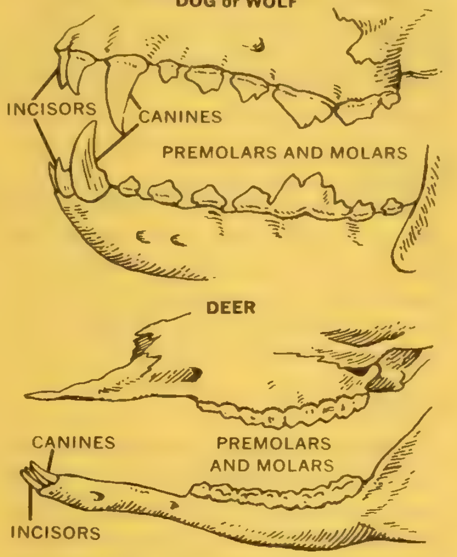
In many homes, a child's prejudice against predatory animals such as wolves begins at the age of two or three. It may last for life. After all, it is easy for a child to "identify" with an industrious little pig or with Little Red Riding Hood. When challenged by facts, however, the myth of the "big bad wolf" may disappear.

To help combat the myth, this article is titled "The Big *Good* Wolf." It is just as silly, however, to call an animal "good" as it is to call it "bad." Since wolves are not capable of making moral judgments, they cannot be judged by the standards of human ethics. Wolves are simply a part of a complex "web of nature" that has evolved over millions of years.

This article tells what biologists have learned about the role of wolves in communities of plants and animals. You might use discussion questions like the ones below to bring out the important concepts of the article.

Topics for Class Discussion

- *How are wolves and other carnivores suited for eating meat but not plants?* Have the children look at the teeth of their pets. They may be surprised to see that cats and dogs (both carnivores) have sharp canine teeth ideal for piercing flesh, and incisors for cutting *(see diagram)*. The teeth of rabbits, horses, and other plant-eaters are adapted for cropping plant food and grinding it up.



Compare the teeth of meat-eaters and plant eaters to see how each is adapted to get and chew different kinds of food.

The digestive system of carnivores is also adapted to a meat diet. Quite a different sort of digestive system is needed to digest great quantities of plant material. Remind your class of the cow's four stomachs.

- *What effects do wolves have on populations of big game animals?* Biologists have discovered that wolves tend to prey on individual animals that are young, old, diseased, or injured. As the author notes, this has been learned by examining the carcasses of animals killed by wolves. The age of moose, caribou, and many other plant-eaters can be determined by looking at the animal's teeth; the animal's health can usually be determined by examining its heart, liver, and other organs.

- *What would happen if the wolves were removed from Isle Royale National Park?* Studies on this unique island laboratory show that the wolves are keeping the moose population in a healthy balance with the plant-eaters' food supply. If there were no wolves to control the moose numbers, the population would rise until other factors, such as disease and starvation, kept the moose in check.

- *Since there are no wolves in most of the United States, what now controls numbers of big game animals?* Populations of deer and other big game animals are now kept in check mostly by hunters and by the amount of available food. In some areas hunters harvest too few deer and food becomes the limiting factor, with some of the deer herd dying each winter of starvation.

References

These books, though written for adults, will make enjoyable reading for your more advanced pupils.

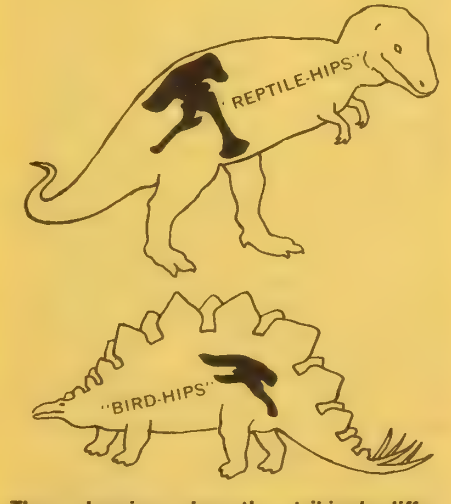
- *A Naturalist in Alaska,* by Adolph Murie, The Natural History Library, Doubleday & Company, Inc., New York, 1963, $1.45 (paper).
- *Arctic Wild,* by Lois Crisler, Harper and Brothers, New York, 1958, $5.50.
- *Never Cry Wolf,* by Farley Mowat, Dell Publishing Co., Inc., New York, 1965, 50¢ (paper).

Dinosaurs

The WALL CHART and the article preceding it are concerned with the evolution of the dinosaurs. The time scale near the bottom of the chart puts the reign of the dinosaurs in perspective. For a more comprehensive chart of evolution, see N&S Wall Chart No. 207, *The Ages of the Earth.*

Point out the early division of all dinosaurs into two distinct groups. Probably the most conspicuous difference between these main evolutionary lines was the arrangement of hip bones, shown in the diagram.

(Continued on page 4T)



These drawings show the strikingly different arrangement of the hip bones of the two main groups of dinosaurs.

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Using This Issue...
(continued from page 3T)

Some people have an image of all the different kinds of dinosaurs living together throughout 100 million years, then suddenly dying out. Emphasize that different species of dinosaurs were appearing and becoming extinct throughout the history of the dinosaurs. And the final extinction, though "abrupt" in terms of the long history of life on earth, still occurred over the span of several million years.

The theories on the causes of dinosaur extinction are discussed in "Why Did the Dinosaurs Die Out?" *(N&S,* Nov. 15, 1963; also available in N&S Resource Study Unit No. 101, *Animals Through the Ages).* For more information about how scientists study dinosaurs through examination of fossil skeletons, see "The Duck-Billed Dinosaur Puzzle" (*N&S,* Oct. 18, 1965), which tells more about the work of Dr. John H. Ostrom.

Inside a Hurricane

No one understands fully how a hurricane forms, but this article will give your pupils a close-up view of the birth, life, and death of a hurricane and an idea of the conditions that produce these violent storms.

You might introduce this article by asking your pupils to relate their experiences with storms that had high winds and heavy rains. Their experiences will give them a better sense of the fury of such storms and the enormous energy they contain.

Topics for Class Discussion

- *Why do weather scientists refer to a hurricane as a "tropical cyclone"?* A *cyclone* is a portion of the atmosphere where the air is moving in a closed circulation and the winds are blowing counterclockwise in the Northern Hemisphere (or clockwise in the Southern Hemisphere). Tropical cyclones occur over certain parts of all tropical oceans except the South Atlantic. Other names for a tropical cyclone are *typhoon* (Japan) *baguio* (Philippines), *cyclone* (India), and *willy-willy* (Australia).
- *Why do weather scientists call warm, moist air "the fuel" of hurricanes?* A hurricane needs heat energy to keep it alive—to keep the air spiraling upward at great speed. This heat comes from water vapor that is formed where the swirling of the wind over the warm and turbulent surface of the ocean speeds evaporation of the water.

When a liquid evaporates, it absorbs heat. (For an example of how we put this process to good use, see "How It Works—Air Conditioner" in this issue.) As the water vapor is carried aloft, it loses heat to the air. When cooled enough, the water vapor condenses, forming clouds and rain and giving off the rest of the heat it absorbed in evaporating.

When the hurricane moves over land or colder water, its supply of water vapor is cut off or reduced, so there is no longer enough heat to keep the air spiraling upward, and the hurricane dies.

Activity

Weather reports on television and radio and maps in many newspapers show the daily position of the eye of a hurricane. During the next two months, the class could use this information to trace the paths of hurricanes on a bulletin board map. Use pins with heads or pennants of different colors for each hurricane, and note the date, time, and speed of the hurricane at each report so their paths and speeds can be compared.

Paths of other hurricanes in recent years might be obtained from your local newspaper's files, and compared with those on the classroom map. From this activity, your pupils should be able to generalize that hurricanes form over subtropical waters and usually dissipate over land.

Quick Counting

This article is based on "Peas and Particles," a unit for the upper elementary grades developed by the Elementary Science Study of Educational Services Incorporated. In this unit, children explore the meaning of large numbers through different kinds of classroom counting activities and pictures, etc. If you are interested in using the Trial Teaching Edition of "Peas and Particles" with your class, write to Mr. Randy Brown, Educational Services Incorporated, P.O. Box 415, Watertown, Mass. 02172.

By working at problems such as how many grains of salt or how many marbles or the approximate number of any other countable things that can be put in a quart jar, your pupils will be confronted with very large numbers. A few strategies for estimating are suggested to help them deal with these large numbers and obtain approximate answers.

Making a guess will be an important first step for most children. Once they have guessed, they will want to know how many countable things really are in the jar. Reading the article and trying the techniques suggested is then a necessity.

Why Do Leaves Fall?

As the article hints, a chemical is produced in healthy leaf blade tissue that keeps the corky abscission cells from forming. The chemical is indoleacetic acid, or *auxin*—the first plant hormone to be found. Today auxin is sometimes sprayed on apple trees to keep the fruit from falling. The "stem" of an apple is similar to a leaf petiole, so the auxin keeps the abscission cells from forming. Another chemical has been perfected which opposes the action of auxin. It is sprayed on cotton plants so that the leaves fall off before the cotton bolls are picked.

Activity

Get some auxin dissolved in lanolin from a biological supply house *(see list below).* Then cut the blades of the primary leaves from several bean plants. On one set of plants, smear the lanolin-auxin mixture on the cut end of the petioles. On the other set, cover the cut end with pure lanolin (available from drug stores).

Notice how soon the petioles fall from each set of plants and compare the effect of auxin with that of lanolin and, of course, with leaves that are allowed to grow normally. (The latter are the control of this experiment; similar control leaves should be used throughout the other investigations.)

Biological Supply Houses

- Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, N.Y. 14603.
- Ward's of California, P.O. Box 1749, Monterey, Calif. 93942.
- General Biological Supply House, Inc., 8200 S. Hoyne Ave., Chicago, Ill. 60620.
- Carolina Biological Supply Co., Burlington, N.C.
- Powell Laboratory Supply Co., Gladstone, Ore.

nature and science
TEACHER'S EDITION
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Do You Grow Chrysanthemums?

by Brenda Lansdown

■ There's an easy way to obtain a pictorial representation of the type of discussion you lead in your classroom. It takes only an untrained observer endowed with a gift of concentration to make the record.

The observer is given a seating plan of the children in the room. He writes numerals in sequence beside the position of each speaker. Usually the teacher speaks first to start things going, so a 1 is written beside the teacher's place. The child who answers has a 2 written next to his seat, the third speaker is indicated by a 3, and so on. After about 15 minutes the numerals are joined in order.

One type of discussion might produce a representation such as Diagram A on the back page. We name this type *chrysanthemum*. Another type might produce a representation such as Diagram B. We call the B-type a *flow chart*.

What kind of questions on the part of the teacher do you think would produce a type A discussion, a chrysanthemum? Why not jot down a few samples of questions which you think produce the chrysanthemum? Label these questions X.

What kind of questions on the part of the teacher do you think would produce a type B discussion, the flow chart? Why not jot down a few samples of questions you think are appropriate to the flow chart result? Label these questions Y.

What the Diagrams Show

By just inspecting the diagrams one can learn quite a lot about what went on. For instance, who never spoke at all? Which children tend to argue back and forth? Which children jump right into a discussion; which hold back? Which children respond most readily to the teacher's questions? Could you hazard a guess as to the type of learning which might be taking place in each of these discussion types? Knowing the right answers? Guessing what's in teacher's mind? Showing off one's knowledge? Making a new suggestion? Relating ideas? Hazarding a guess?

Here are two records of discussions. As you read each try to label it A (chrysanthemum) or B (flow chart). See whether the X and Y type questions which you wrote down fit in their related places (X with A and Y with B).

Discussion I

Some fourth grade boys had been given compasses to experiment with along with some magnets. The children had said that north and the other compass directions vary according to where you stand. The next session the teacher brought in a new piece of equipment, placed it on the table and gave each boy a compass. The following discussion took place after the children had experimented for a while:

Teacher: Anyone know what this is?
Ole: It's a plastic globe . . . blue . . .
Dick: It's where you find the U.S.
Ole: You're crazy – it's the whole world!
Dick: It's not the whole world – is it? (Pokes Nick.)
Nick: Yeah, it is . . . (busy with compass, holding it to the North Pole).

(Continued on page 8T)

Brenda Lansdown is an Associate Professor of Education at Brooklyn College of The City University of New York. These discussions were observed and recorded by Elizabeth Welsh and Joan Crunden during a summer course given at Harvard University by the author.

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 7T.)

● **Perpetual Motion Machines—Are They Possible?**
Your pupils can find out how friction wastes energy, making it impossible for a machine to run very long without more energy being supplied to it from outside.

● **How Did Spiders Become Spinners?**
We will probably never know for sure, but scientists have several ideas about how this unique kind of behavior evolved.

Eight Ways To Catch an Insect
These examples of how different kinds of spiders catch their prey may launch your pupils on a web-finding and watching expedition.

Sky Watching at Midnight
By checking the positions of certain stars at dusk, midnight and dawn, your pupils can find out how the earth's rotation affects our view of the stars.

Hay, Hay, Hay and a Bucket of Blood
A fascinating story of a scientist who found a substance that makes cows sick and humans well, then put it to work exterminating rats.

● **How It Works—Speedometer**
This dashboard computer keeps track of how fast a car is going by "imitating" the turning of its wheels.

IN THE NEXT ISSUE

A special-topic issue on sound: Making and changing sound waves... What noise does to us and what we can do about it... A WALL CHART on sound waves... How bats "zero in" on their prey... Sounds in the sea... The ear.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Perpetual Motion

Your pupils will probably be fascinated by the "Rube Goldberg"-type machines pictured with this article. They were supposed to supply their own energy and keep running forever without getting any fuel or energy from outside. Some were supposed to do useful work as well.

The article explains why such machines can't be made to work: You can't get more energy from a machine than you put into it; in fact, you can't get *as much* because some of the energy is used up in overcoming friction.

You might use this article as a springboard or supplement in teaching a unit on friction or on energy, machines, and work.

Topics for Class Discussion

- *Does friction destroy energy?* No. Energy can be changed from one form to another, but—except in nuclear reactions—it cannot be created or destroyed. Friction changes mechanical energy (the push you give a wheel to make it spin) into heat energy. This heat energy is transferred to the molecules of the gases that make up the air, making those molecules move around faster than before.

- *If you could find a way to capture the heat energy produced by friction and put it to work, could you make a perpetual motion machine?* No. Whenever you "spend" energy, or put it to work, you must pay a "tax" of a certain amount of energy that is changed into heat and lost to the atmosphere. So even if you could use some of the heat energy produced by friction, some of it would be lost.

Why Won't This Machine Work?
The machine shown at the end of the article will not work because a magnet strong enough to pull the iron ball up the groove would not let the ball fall through the hole.

- *What does the term "perpetual motion" mean?* Literally, just "movement that continues forever." But historically, and in science fiction, the idea of perpetual motion has usually been associated with machines that would run continually, making enough energy to keep themselves going and run other machines at the same time. There is a difference, then, between perpetual *movement* and perpetual motion *machines.*

- *Is perpetual movement possible?* As the article points out, atoms seem to be in a state of perpetual movement (vibration). And scientists have produced what seems like a kind of perpetual movement with electricity. This was done by cooling a ring of metal wire to a temperature near absolute zero. At that temperature, certain metals lose all of their resistance to the flow of an electric current. So when a certain amount of electricity is sent into the wire ring, the current keeps flowing around and around without losing any energy.

You could tell your pupils how this continually flowing current is achieved and ask them to think about its possibilities as a perpetual motion machine. It has no such possibilities, for two reasons: 1) It takes a constant supply of energy from outside to run the pumps that keep the wire ring cooled to the proper temperature; 2) If any of the current were drawn out of the ring to run, say, an electric motor, the current in the ring would soon be used up.

- *Why were so many attempts made about three to four hundred years ago to design a perpetual motion machine?* (Your pupils may notice that the machines shown in the article were mostly designed in the 1600s.) In Europe, men began in the 1300s and 1400s to make complicated machines to do such work as grinding grain or weaving cloth. But steam engines had not yet been invented, and the only sources of energy to run the new machines were humans, other animals, water wheels, windmills, and falling weights. People and other animals have to be given energy in the form of food. And it takes energy to lift a weight up so that it can be pulled downward by the force of gravity. Water wheels require a steady supply of flowing or falling water, and windmills turn only when the wind is blowing. Furthermore, little was known about heat and friction at that time. So the men who were designing machines to do different kinds of work tried to design machines that would produce enough energy as they ran to run themselves and other machines too.

It's interesting to note that energy in the form of heat was the key to the problem. A perpetual motion machine can't work because its energy is wasted as it is changed into heat by friction. A steam (or gas or diesel) engine gets heat energy from chemical energy by burning coal or oil products, and changes the heat energy into mechanical energy that can be used to run other machines.

- *Is it true that "You can't get something for nothing"?* No. There are a lot of things you can get for nothing—*but not energy.*

Spiders into Spinners

In this article, Alice Gray of the Entomology Department of The American Museum of Natural History traces two ways in which spider webs may have evolved. Because web-spinning began about 3,000 million years ago, we will never know for sure how it did start.

The article hints at the workings of *natural selection*—the guiding factor of evolution. *(For another example, see the* WALL CHART *"The Hidden Animals,"* N&S, *May 9, 1966.)* Briefly, natural selection works in this way: In every species there are hereditary differences; seldom are two individuals exactly alike. Also, each generation of a species usually produces far more young than can be supported by their environment. Because of this there is competition between individuals for

(Continued on page 7T)

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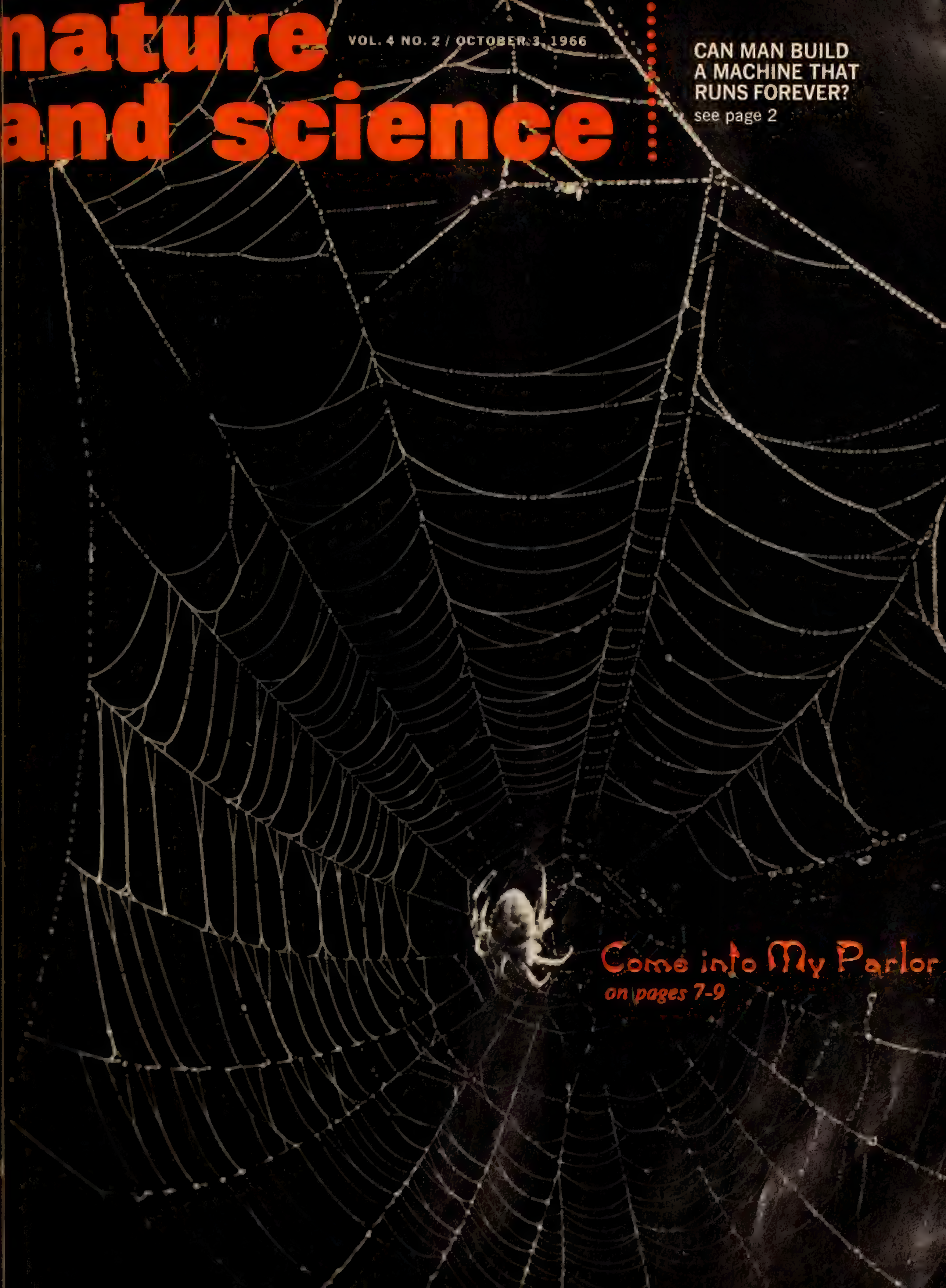
CAN MAN BUILD
A MACHINE THAT
RUNS FOREVER?
see page 2



Come into My Parlor
on pages 7-9

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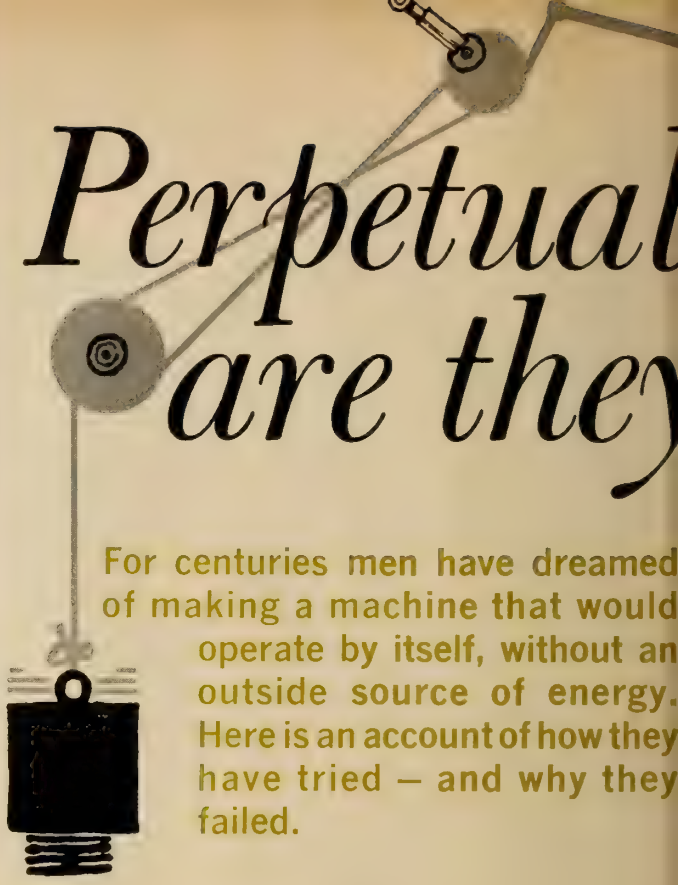


Perpetual
are they

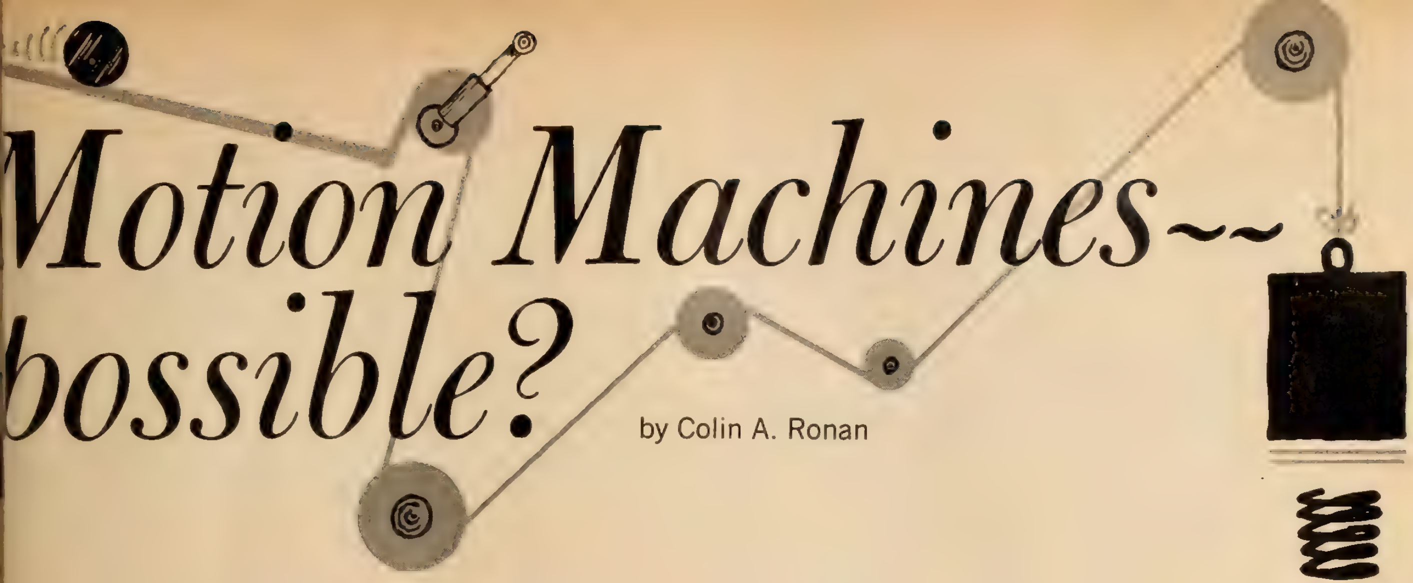
For centuries men have dreamed
of making a machine that would
operate by itself, without an
outside source of energy.
Here is an account of how they
have tried – and why they
failed.

■ Some people have always been trying to get somethin
for nothing. They include inventors who have tried t
make a perpetual motion machine—a machine that woul
run forever without needing any fuel or energy from ou
side to keep it running. They believed that if they coul
just find the right design, the machine would provide i
own power as it ran. The machine would not only kee
itself going, but would also do useful work, such as grinc
ing wheat or pumping water. Some of the designs tried b
inventors are shown on these pages.

The men who tried to make perpetual motion machine
knew that falling water or weights could be made to tur
a wheel or move a lever. The question was, would th
moving wheel or lever have enough energy to lift th
weights or water back up to the place they fell from, thu
continuing the cycle? And if so, would there be enoug
energy left over to do some additional work, such
grinding wheat?

The machine in Drawing 1 made use of a kind of pum
that had just been invented; but, as the caption explain
the machine could not be made to work. Inventors turne
again and again to water wheels and to a kind of "wate
elevator" called the *Archimedes screw*. The water whee
turns when water falls on its paddles and gives the whee
a push. The Archimedes screw lifts water along a spira
track or through a spiral tube when the screw is turnec

Many inventors thought that a water wheel could b
made to turn an Archimedes screw, which would lift th
fallen water back up to a point where it could fall on th



Motion Machines--
ossible?

by Colin A. Ronan

ater wheel again. Drawing 2 (*see next page*) shows a achine that was supposed to work this way and turn a rinding wheel at the same time. Drawing 3 shows a similar achine that used cannon balls for weights instead of ater. The captions explain why these machines could not e made to work without some kind of help from outside.

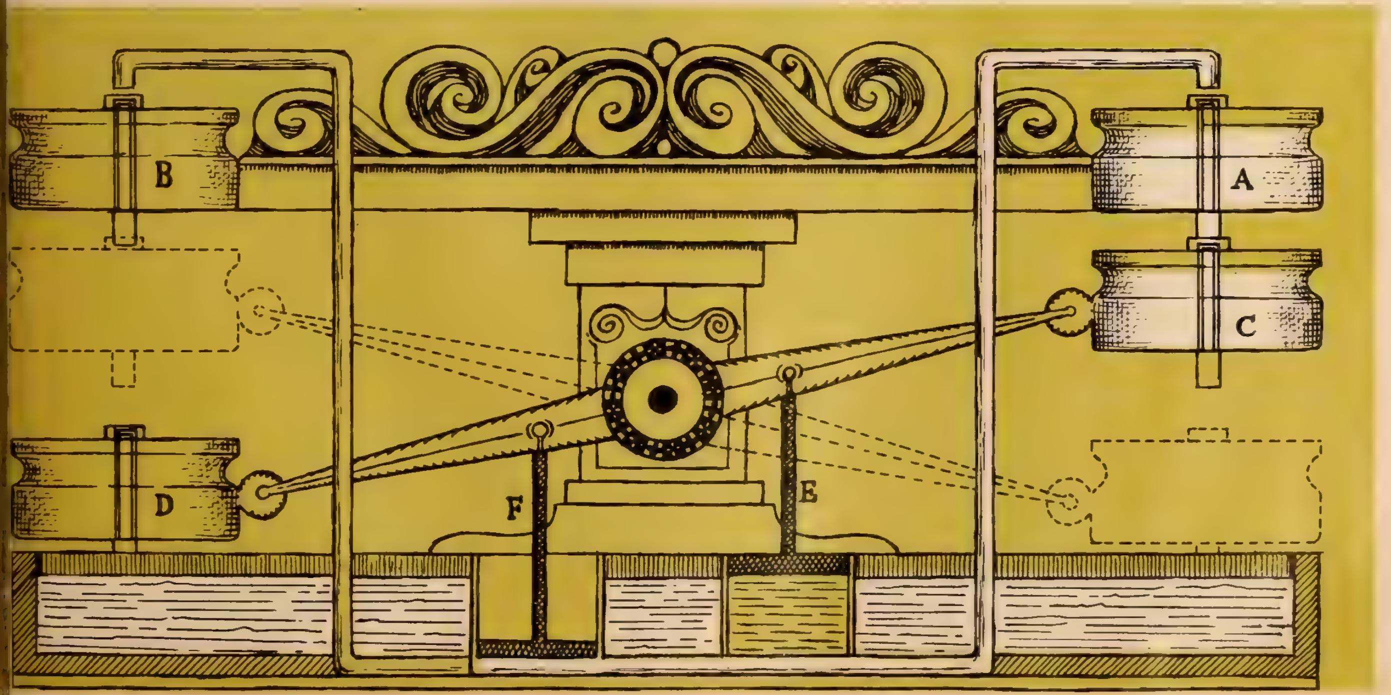
hy Won't Perpetual Motion Machines Work?

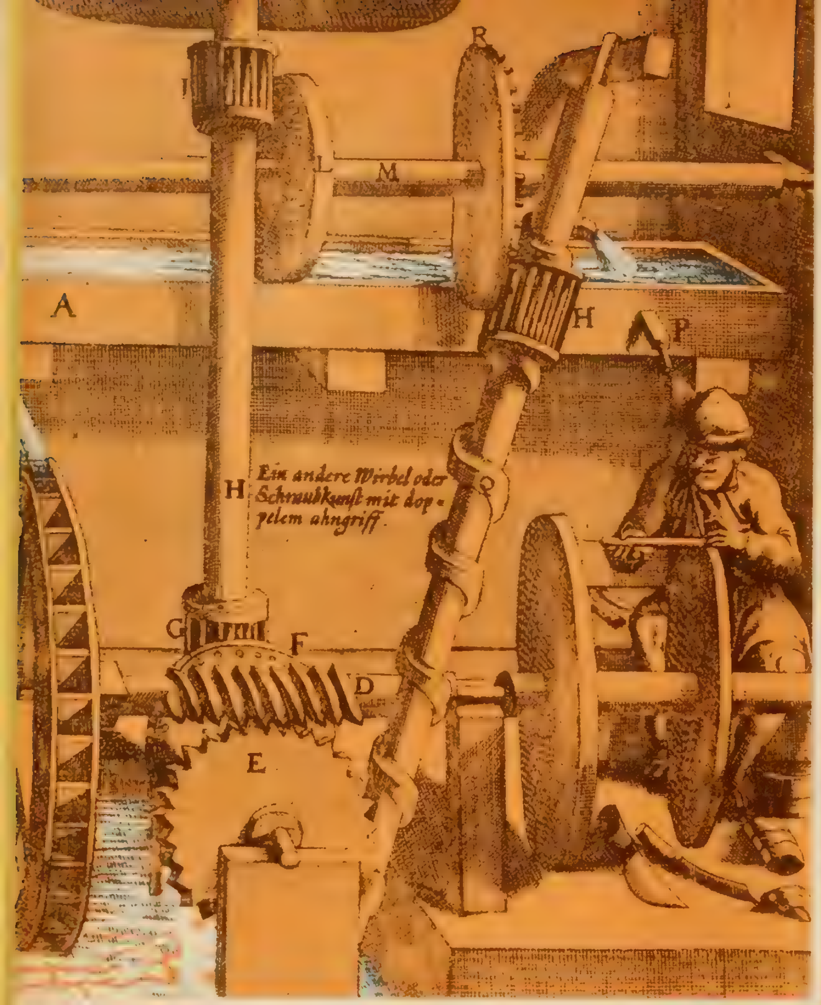
Perpetual motion machines will never work. They must always get energy from an outside source. The reason for this is that all machines waste some of their energy when they run. You can see this by giving the front wheel of a bicycle a spin when the bicycle is standing upside down. Although the wheel spins for a long time, eventually it comes to a stop, unless you give it another push.

You can get a good idea of why this happens by rubbing the palms of your hands together rapidly. Each time

(Continued on the next page)

1 PERPETUAL MOTION BY PUMPING. In this machine, *A*, *B*, *C*, and *D* are small water tanks. *E* and *F* are pumps. ank *D* is emptying its water into the main tank at the bottom, while tank *C* is being filled from tank *A*. When *C* is lled, it is heavier than the empty tank *D*, and it moves ownward. Tank *D* moves upward and the pump *E* pumps ater to the left-hand tank *B*. When *D* reaches tank *B*, it fills and, at the same time, tank *C* empties. Tank *D* now moves downward, *C* moves upward, and the pump *F* pumps water into tank *A*. This machine, designed in 1661, will not work because some of the energy of the filled tank moving downward is wasted by friction—at the center post, in the pumps and inside the water pipes. Not enough energy is left to pump water back up the pipes.



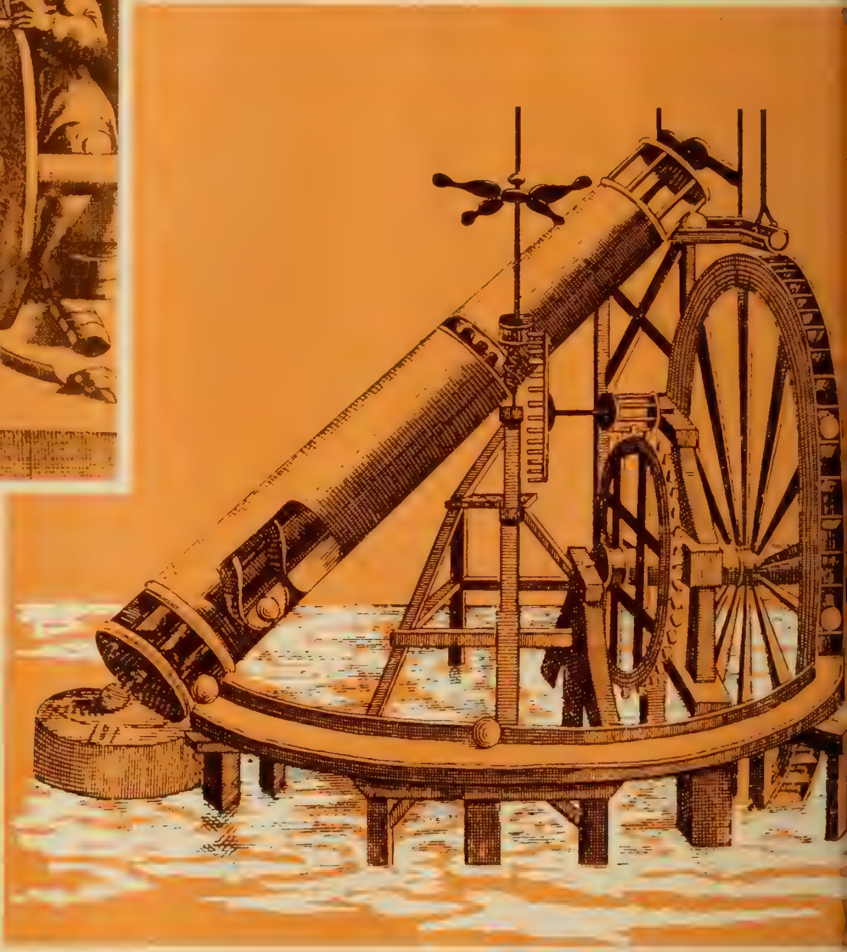


2 KNIFE GRINDING BY PERPETUAL MOTION.

Water from the upper tank A drives the water wheel C. The wheel, in turn, drives the grindstone where a man is shown sharpening knives. The water wheel also turns several gears which power the Archimedes screw Q, lifting water back up to the tank. This machine would not work because the water wheel would not have enough energy to operate the grindstone, the screw, and the gears. Friction would be too great.

3 PERPETUAL MOTION BY WEIGHTS.

Iron balls dropping onto the water wheel were supposed to make the wheel go round. A gear system driven by the water wheel turned the Archimedean screw and the screw lifted the balls up to the top of the wheel again. The inventor of the machine insisted that it must always stand in a pool of water. The machine would not work, not even if the extra friction created as the wheel turned through the water were removed by draining the water away. However, the inventor claimed that it worked very well. We can only imagine that the pool of water was needed to hide the real machinery that drove the water wheel. This, surely, was a case of faked perpetual motion.

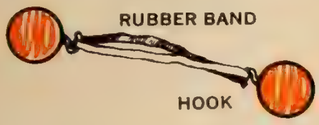


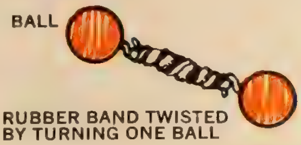
Perpetual Motion Machines (continued)

your palms rub together, some of the energy of motion you gave your hands is changed into heat energy. You can feel your palms get warmer and warmer. But when you take your hands apart, they get cooler at once. The heat is carried away from your skin by the air that is touching it.

The turning wheel rubs against the axle, and its spokes, rim, and tire rub against the surrounding air. This rubbing action, called *friction*, gradually changes the wheel's energy of motion into heat energy, which is carried off by the air. When all of the wheel's energy is used up, it stops turning. Friction, then, is mainly what prevents a perpetual motion machine from working.

Could you make a machine that would run forever if you were able to do away with friction and didn't try to take energy away by making it run another machine? Here's one you might try. Take two smooth small wooden or metal balls, and fit a hook on each ball. (You might use screw-hooks or fasten the hooks to the balls with strong glue.) Now put a rubber band between them (*see diagram*) and twist one ball around until the rubber is tightly wound. Next, place the balls on a smooth sheet of glass or plastic and let go.





You will find that the rubber band untwists and rolls the balls apart. When the rubber is untwisted, the balls are rolling very fast. They go on rolling and so twist up the rubber band again. When the rubber band is wound up, the balls stop rolling for an instant, and begin rolling in the opposite direction as the rubber band untwists again. And so it goes for a time, but eventually the balls stop rolling.

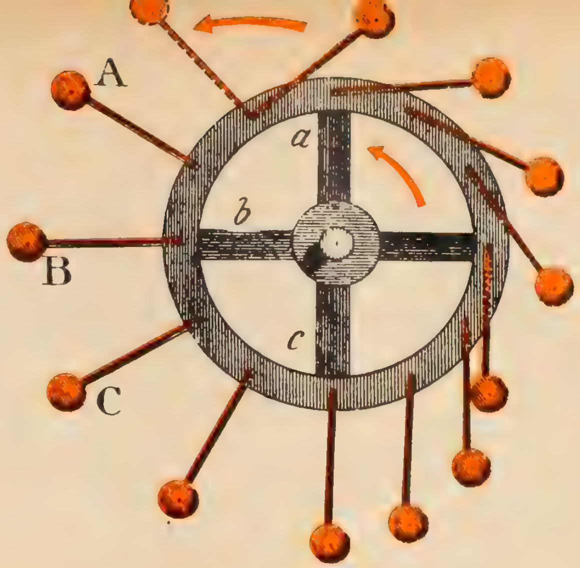
Some energy, of course, is lost to friction as the balls roll on the glass. But also, every time the rubber band twists up, some energy is used up in stopping the balls from rolling. And as the rubber next untwists, more energy is used up in starting the balls rolling again. So even if there were no friction this machine could not keep going forever.

Perpetual Motion among the Stars?

What about the moon, planets, and stars, you may ask. Surely they are in perpetual motion—the moon around the earth, the earth around the sun, and the sun and other stars around the center of the galaxy. None of this is true perpetual motion. We have merely come across moving objects that produce so little friction that their motion, once started, lasts for billions of years. Although the planets and stars move through gas and dust in space, the friction slows them down hardly at all; no more than an elephant is slowed down by bumping into a mosquito.

Within the tiny kingdom of the atom we meet with what seems to be true perpetual motion. Atoms are always vibrating—always moving to and fro. In a crystal of ice, or of salt or sugar, the atoms vibrate all the time, even when there is no other energy supplied from the outside. Scientists are not certain about how this happens, but they know that gravity and friction do not affect the motions of atoms in the same way as they affect things in our everyday world.

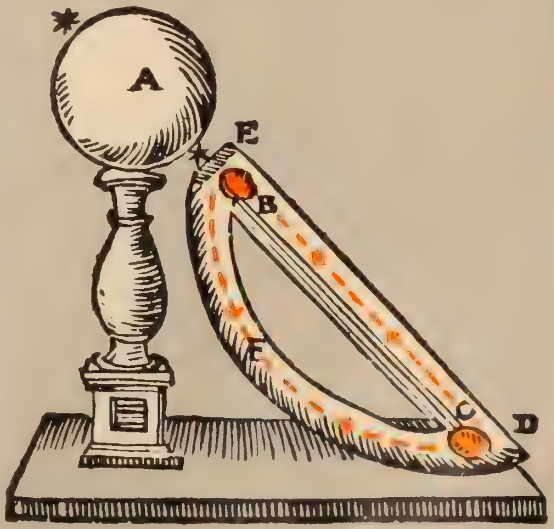
But the atom is, at best, an example of perpetual motion; not of a perpetual motion machine. Even a nuclear reactor, in which atoms are smashed to get energy to make electricity, must be refueled now and then. Whatever you do —run, ride a bicycle, roll a bowling ball, or turn an electric generator—friction is always changing part of the energy you produce into heat, which is lost to the air. This is what makes a perpetual motion machine impossible ■



4 PERPETUAL MOTION BY WEIGHTS. **As the wheel turned in the direction *abc*, the weights at the end of arms *A*, *B*, and *C* soon flipped outward. They were supposed to act as levels and force the wheel around. They were also supposed to lift the "dead" weights on the opposite side of the wheel to the top again. Friction generated by the wheel turning on its axle would prevent such a machine from running indefinitely.**

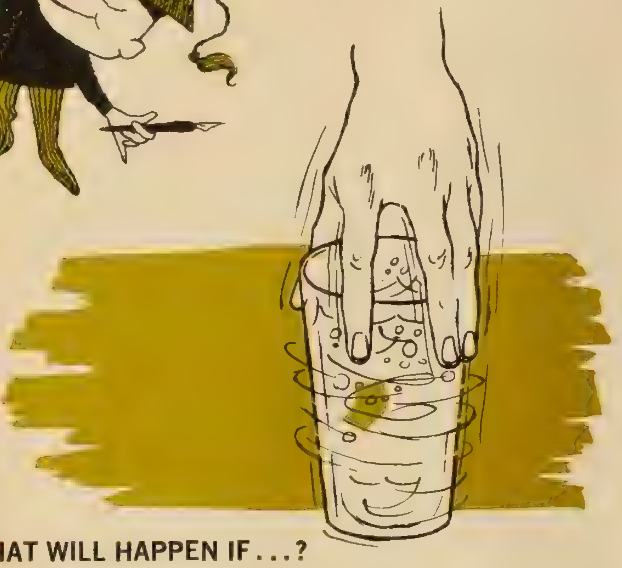
WHY WON'T THIS MACHINE WORK?

In the year 1643 a German inventor designed this "perpetual motion" machine. The ball-shaped magnet (*A*) has poles marked by two stars. A lump of iron at position *D* was supposed to be pulled up the groove *CB* by the magnet. When the iron lump bumped the magnet at *E*, the lump was supposed to slide down along the path *EFD* and then be pulled up the groove again, and so on. There is at least one good reason why this machine could not be made to work, even if the magnet were strong enough to pull the lump of iron up the groove. Why won't it work?



brain boosters

prepared by **DAVID WEBSTER**

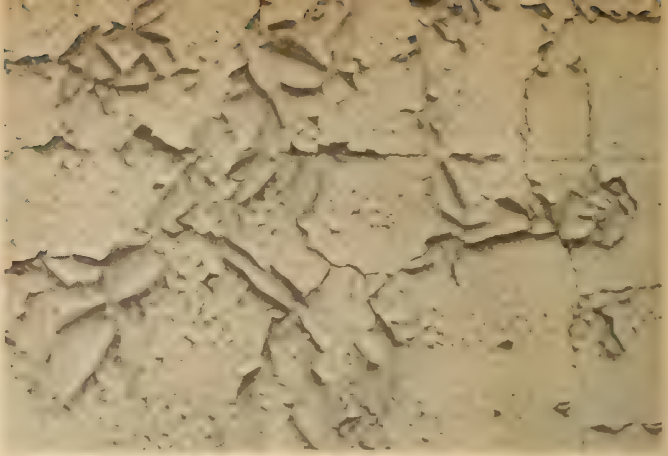


WHAT WILL HAPPEN IF . . . ?

. . . you turn a glass of water around several times? (The motion of the water will be easier to see if you put in a tiny piece of paper.) Does the water spin as fast as the glass? How long does the water keep moving?

JUST FOR FUN

Put a little pile of salt in the center of the bottom of a drinking glass and spin the glass. The salt will go to the outside. Then put some water into the glass with the salt and stir the water around with a spoon. Now the salt goes to the center.



MYSTERY PHOTO

What is it?

FUN WITH NUMBERS AND SHAPES

Which total will be greater at the end of the 1966 baseball season: the runs scored in each game by the Los Angeles Dodgers added together, or the runs scored in each game by the New York Yankees multiplied together?

Submitted by Ronald Edinger, Suffern, New York

FOR SCIENCE EXPERTS ONLY

What happens to a light bulb when it "burns out?"

CAN YOU DO IT?

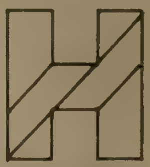
Can you lay a bottle on its side and pour a cup of water into it by using only your hands?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The photograph of the ocean was taken in New Jersey. If you were facing the ocean, the shadows would be going to your left. Since the noontime sun never is in the northern part of the sky in the United States, the ocean must be toward the east. In Australia, would you see noontime shadows like this in Sidney or in Perth?

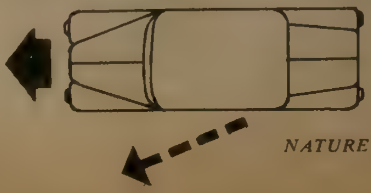
Can you do it? You can get a square picture of light from a round hole by shining some indirect light through a square hole and then through a larger round hole.

What would happen if . . . ? The match box with the weight on top would be harder to blow over than the match box without the weight.



Fun with numbers and shapes: Here is how to make a big "H" from the 6 shapes.

For science experts only: If an apple is thrown straight out the window of a moving car, it will travel in the path shown below. How would it go if it were thrown out harder?



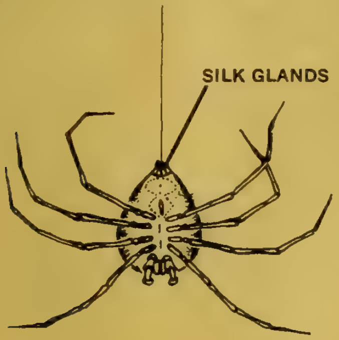
How did spiders become spinners?

by Alice Gray

■ Spiders are easily the best spinners in the animal world. But 300 million years ago, the ancestors of spiders must have been wandering hunters that made no silk at all. How did spiders become spinners? Nobody knows; but after studying the ways in which present-day spiders make silk and use it, scientists have some ideas about how it could have happened.

In some insects, such as silkworms, glands in the mouth that once produced saliva gradually became silk glands. The thread is spun from the mouth of the insect. The same thing has happened in some close "cousins" of spiders, such as spider mites and false scorpions.

But spider silk is *not* a special kind of saliva. It comes from the other end of the body. The silk comes from pairs of glands at the rear of a spider's body (*see diagram*).



Many relatives of spiders have glands in that same general location. Called *coxal* glands, they *excrete*, or give off, body wastes. Probably the silk glands of spiders were once coxal glands. Spider silk probably developed from a waste product that just happened to be useful.

A Silk-Lined Retreat

Imagine a primitive spider with several pairs of glands on the bottom of its body. From the glands oozes a sticky fluid, forerunner of the *dragline* that all spiders leave behind them today. Imagine, too, that this spider hunts by night and has a retreat under a stone to which it returns in the daytime. Gradually the retreat becomes lined with dried waste matter, and strands of this gum spread out from the mouth of the burrow like a fan. A passing insect, stepping on a strand, sets up a vibration that can be felt by the spider crouching within. The spider has only to pop out of its door to catch its food.

A spider whose excretion was elastic, not brittle, had a good insect alarm and did not often have to go out hunting. One that learned to make a doormat all at once, instead of having it build up gradually, hardly ever had to leave home. Such a spider might have been more successful in getting food than spiders without a "doormat alarm system." This spider would be more likely to survive and have young, and the spider's young would also make simple webs. Gradually, over millions of generations of spiders, more complex webs may have evolved from this beginning.

Some scientists think this is how spiderwebs began. Others think that spiders first used the gummy stuff from their coxal glands to strengthen their egg cases. Some of the spiders carried the cases with them and some left them in nest burrows, but the spiders that hunted among the leaves of plants hung their egg cases from stems and twigs with a few strands of silk.

Most of the time the mother spider stood guard over the eggs. Even when she had to leave them to hunt for food she soon returned. Every time she came and went she added a thread to the tangle of silk that grew around the hanging egg case. Of course, if a flying insect blundered into the net, the spider had a good chance of catching it. This may also have been a beginning of webspinning.

Webs of Many Kinds

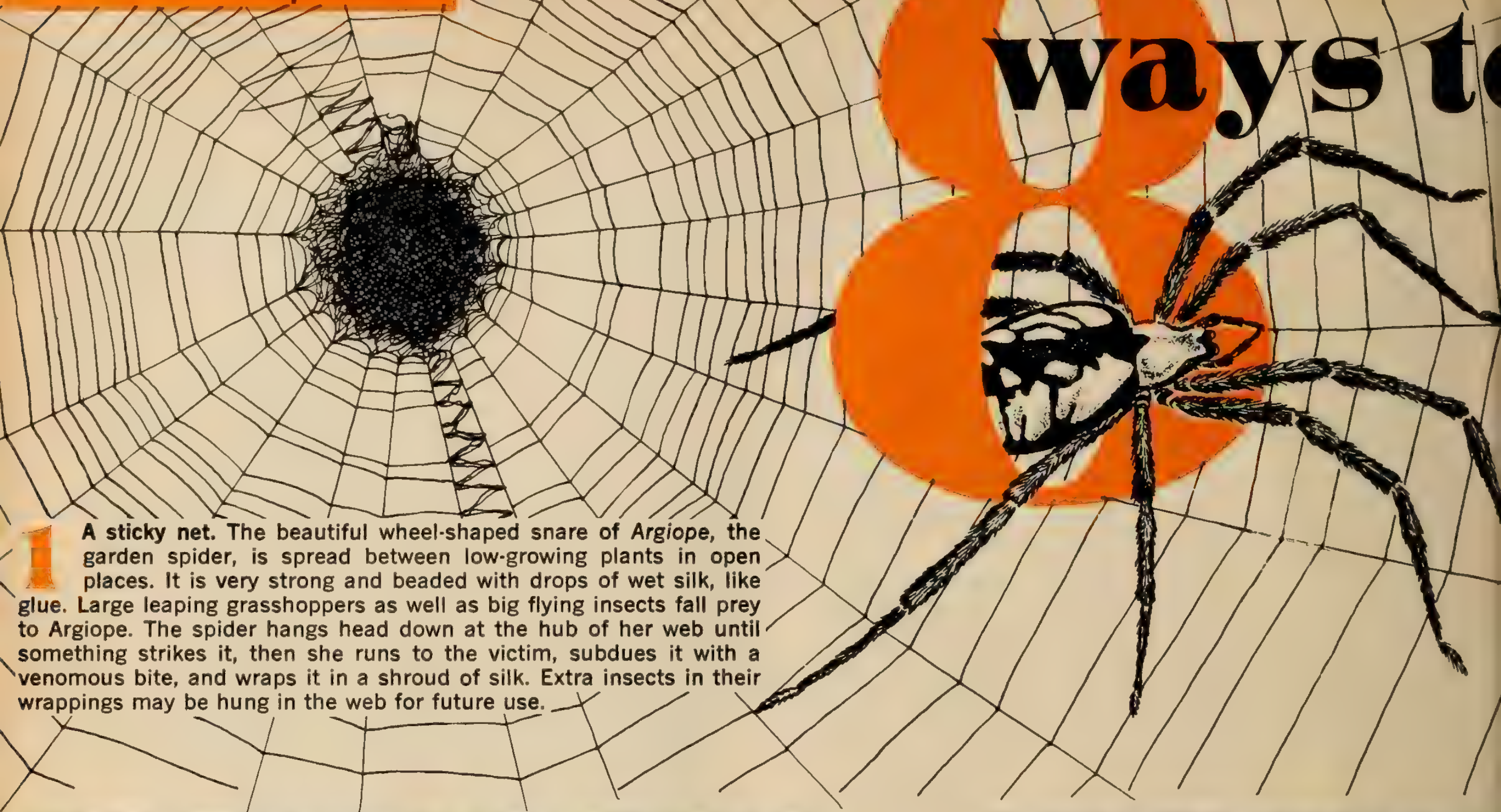
However spiders started spinning them, webs developed in many different ways. The shape became better suited for catching insects and other prey. By adding sticky threads or bands of tiny snarled threads, spiders kept the insects from escaping before they could be seized. Today, webs of different forms trap insects of different habits *(see the next page)*.

Some kinds of spiders that once spun webs have now abandoned this way of life. They are closely related to web makers. In some species the baby spiderlings spin webs, but the adults no longer do. These kinds of spiders have returned to the free hunting habit their ancestors followed 300 million years ago. We can only guess why ■

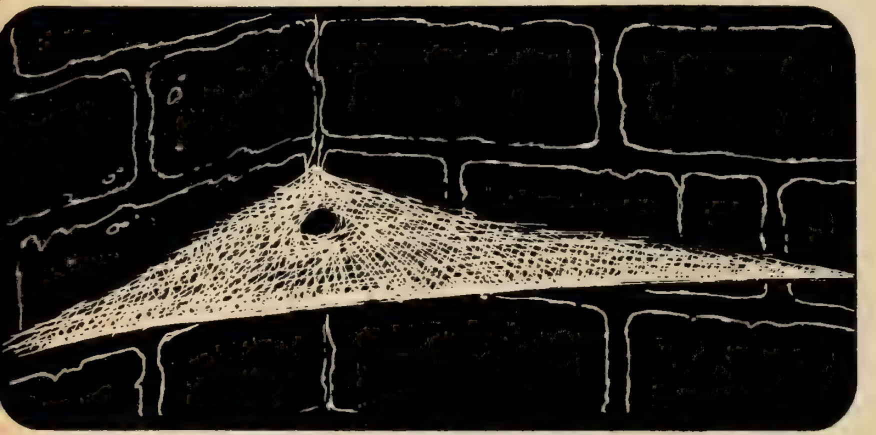
Two good books on spiders are: **Spiders and How They Live,** by Eugene David, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1964, $2.95, and **The Web of the Spider,** by Laura B. Lougee, Cranbrook Institute of Science, Bloomfield Hills, Michigan, 1964, $3.50.

nature and science | WALL CHART | October 3, 1966

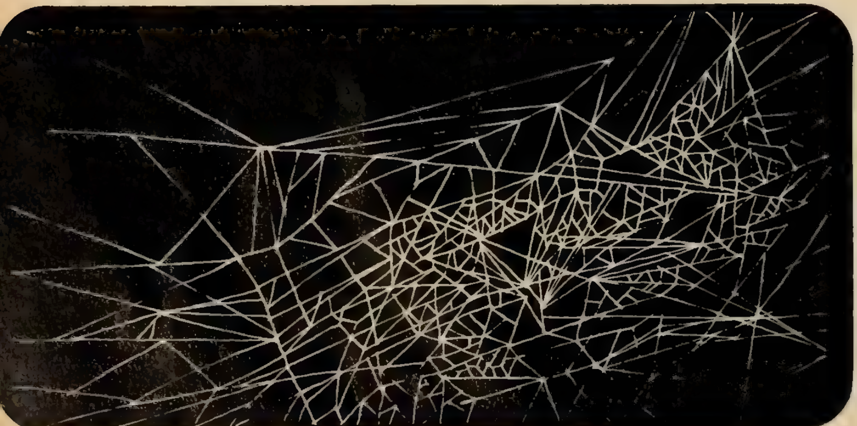
8 ways t



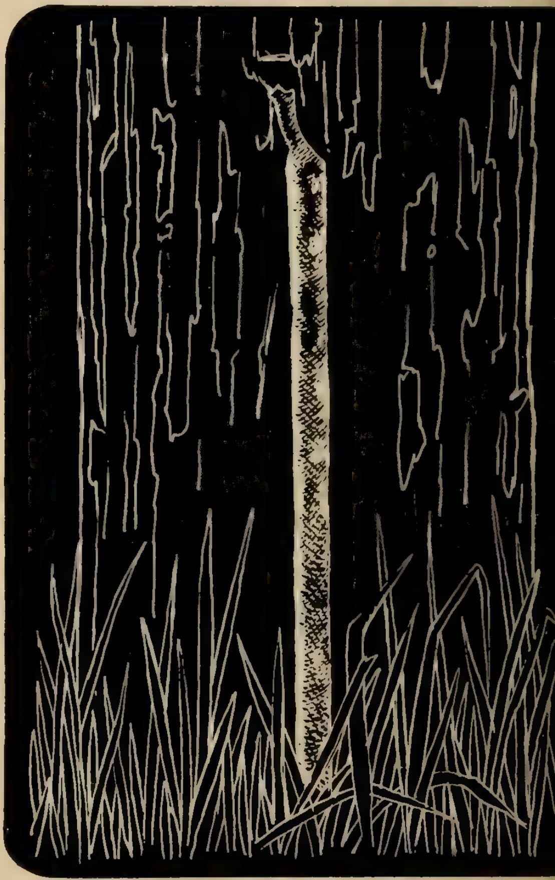
1 **A sticky net.** The beautiful wheel-shaped snare of *Argiope*, the garden spider, is spread between low-growing plants in open places. It is very strong and beaded with drops of wet silk, like glue. Large leaping grasshoppers as well as big flying insects fall prey to Argiope. The spider hangs head down at the hub of her web until something strikes it, then she runs to the victim, subdues it with a venomous bite, and wraps it in a shroud of silk. Extra insects in their wrappings may be hung in the web for future use.



2 **A silk tube with an apron.** The footsteps of an insect alighting upon or crossing the apron alert the spider, *Tegenaria*, waiting inside the tube. Look for this web in cellars and sheds.



3 **A tangled maze of dry threads.** The long-legged cellar spider, *Pholcus*, makes a big web like this. When the spider is disturbed, it bounces the web violently. This helps to entangle any insect that may have blundered into

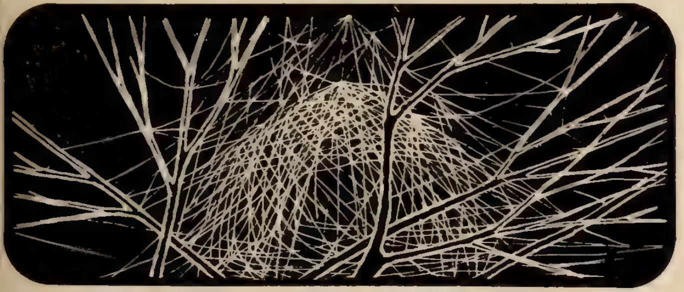


4 **An ambush.** The purse-web spider, *Atypus*, ma
this camouflaged tube. Part is underground
part against the trunk of a tree. The spider wait
the tube just below ground level until the tread of ar
sect on the upper part of the tube arouses her.
strikes through the wall of the tube with her fangs to s
due the prey, then tears a hole through which to drag
insect in. After dinner, the spider mends the hole
throws the dry husk of the insect out at the top of
tube. Purse-web spiders live in wooded parts of the so

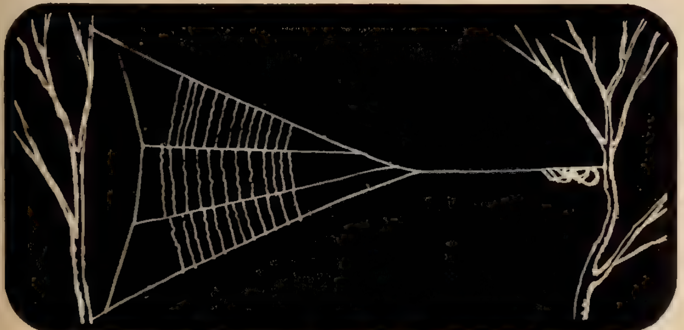
catch an insect

In the millions of years since spiders began using ilk to catch their food, webs of many forms have volved. Here are a few of them. Each of these webs raps insects of particular sizes and habits, and they ork in somewhat different ways. All the webs shown re found in North America, and most of them are ommon. Try looking for them. You will find forms ike these and many more. With patience, you can earn what kind of spider made each web, how the web works, and what kind of insects are most lik to be caught in it. (This chart is not intended to h you identify spider webs, since different spid make webs that are very much alike.)

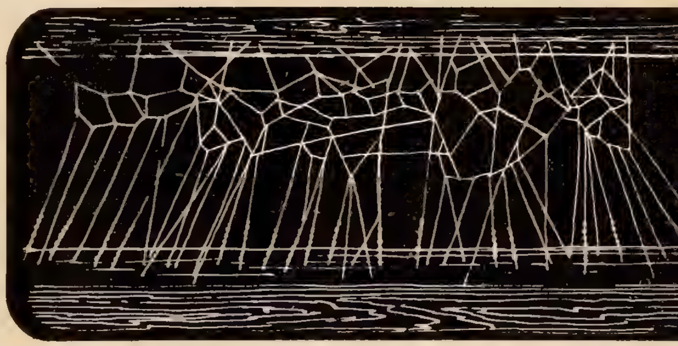
Watch at night and very early in the morning well as in broad daylight. (A flashlight will bother the spider.) Many kinds of spiders k strict working hours—the hours when the ins upon which they prey are active.—ALICE GRAY



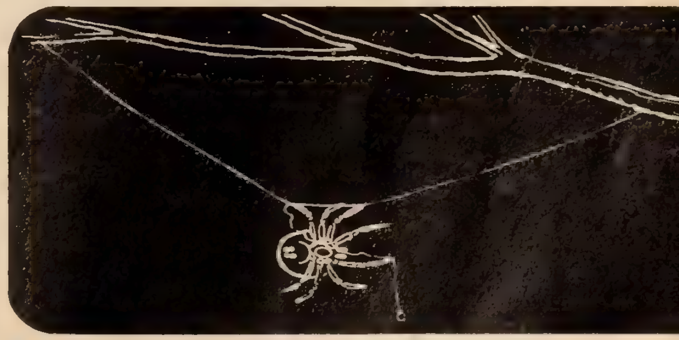
5 **A sticky maze-and-sheet web.** So delicate is the home-and-trap of the filmy-web spider, *Linyphia*, that it is hard to see. You will find it among plants in cool, damp, shady places. The spider hangs upside down under the dome. The silk of the web is only slightly tacky—just enough to hamper a flying insect. When an insect is caught, its struggles usually bring it down to the web's dome. Sometimes the spider shakes the web to hurry the fall of its victim onto the dome. The prey is pulled through the dome and wrapped in bands of silk before being eaten.



6 **A spring trap.** The web of the triangle spider, *Hyptiotes*, is usually strung between the twigs of a dead branch. It is made of four threads of dry elastic silk crossed by many *hackled* bands—threads made of tiny claw-catching loops of sticky silk. From one corner of the triangle a single line leads to a nearby twig. Here the spider hangs, pulling hard on the line to keep it taut. When an insect flies into the web, the spider lets go,



7 **A gum-footed maze.** *Theridion*, the maker of this web, lives to the ground and captures walking and low-flying creat Taut lines from the bottom of the irregular net are fast to the ground and beaded at the foot with silk gum. A flying in striking the maze, falls to the bottom of the trap and gets stuc walking insects do. If the struggles of the prey break the taut l they contract and hoist the victim off its feet.



8 **A bolas.** A bolas spider, *Mastophora*, uses a web that resen the device used by Argentine gauchos to capture wild catt is a single thread with a big drop of wet silk at the end. spider feels (or perhaps hears) the wingbeat of an approaching n and swings the sticky globule toward it. If she makes a strike, pulls in her line, bites her victim, and wraps it in silk. Lool *Mastophora* in the autumn, after dark. You will find her hanging h

Sky Watching at Midnight

by Donald Ford

■ Are the same stars out all night?

Make plans to look at the stars at midnight some night in the first few weeks in October. You will want to plan to first look at the stars at dusk, and then again when it is dark, to become familiar with a few bright stars. Set your alarm for midnight and go to bed early. At midnight, look at the sky again. Before going to bed again, reset your alarm for dawn so you can see the stars once more before the sun rises. Try to choose a clear night.

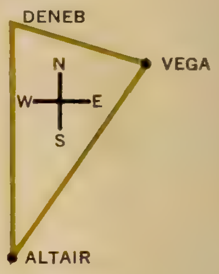
AT DUSK: Night does not arrive all of a sudden; it comes slowly. After sunset, the sky changes from blue to gray to black. The time of day between sunset and darkness is called *evening twilight*. The first star appears during dusk. Then another star appears, and another, until the sky is dark and full of stars.

See if you can find the first star. Can you find that first star again when the sky is dark and full of stars? In what way is the first star different from the stars that appear later? Do you think it is brighter? Or is it just in the part of the sky that gets dark first?

Will the same star be the first one you can see on two or three clear nights in a row? Will the same star be the first star every night during the year?

One star that might be the first one you see early in October is called Arcturus. You will be facing in the direction in which the sun went down (west) and you will be looking up about 30° from the horizon.

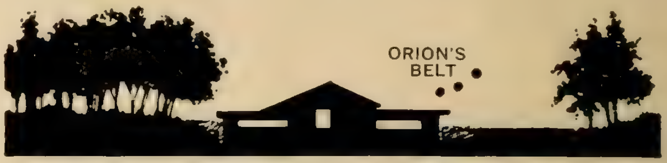
Another star that could be the first star you see is called Vega. It will be almost directly overhead.



Vega and two other bright stars form the Summer Triangle. To find it, face south and hold this diagram over your head.

AT MIDNIGHT: Can you find the first star you saw at dusk again at midnight?

You will now be able to see Orion's Belt, which you could not see in the early evening. Look in the direction where the sun rises, and close to the horizon. You should see three medium-bright stars close together and in a line.

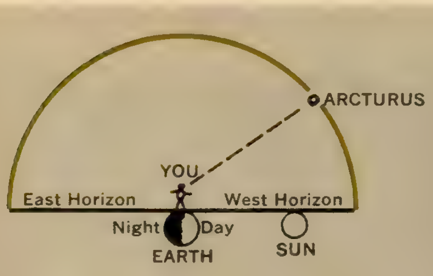


Where was Orion's Belt in the early evening?

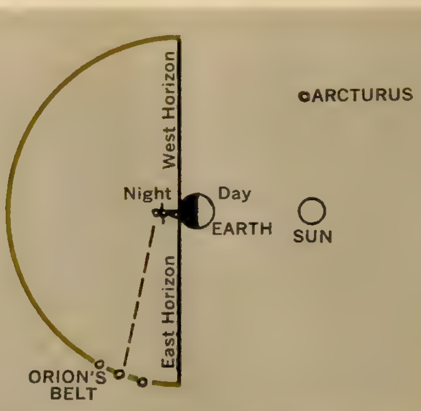
The stars appear to move toward the west because the earth turns toward the east *(see diagrams)*. Because the earth turns, our view of the stars is continually changing ■

PROJECT

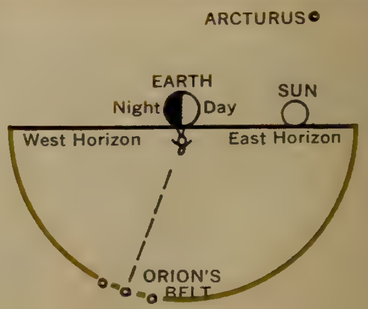
By the end of December and early January will you be able to see Orion's Belt in the early evening? Try to find out. (Watch for the January 9th issue of *Nature and Science*. At that time we will print an article that will help you answer that question.)



1 At dusk you will see Arcturus above the western horizon. You will be standing close to the edge of day (the part of the earth in sunlight) and night. The earth turns toward the east, or in a counterclockwise direction as viewed from above the North Pole.



2 By midnight, the half of the sky that you see will be different because the earth has turned.

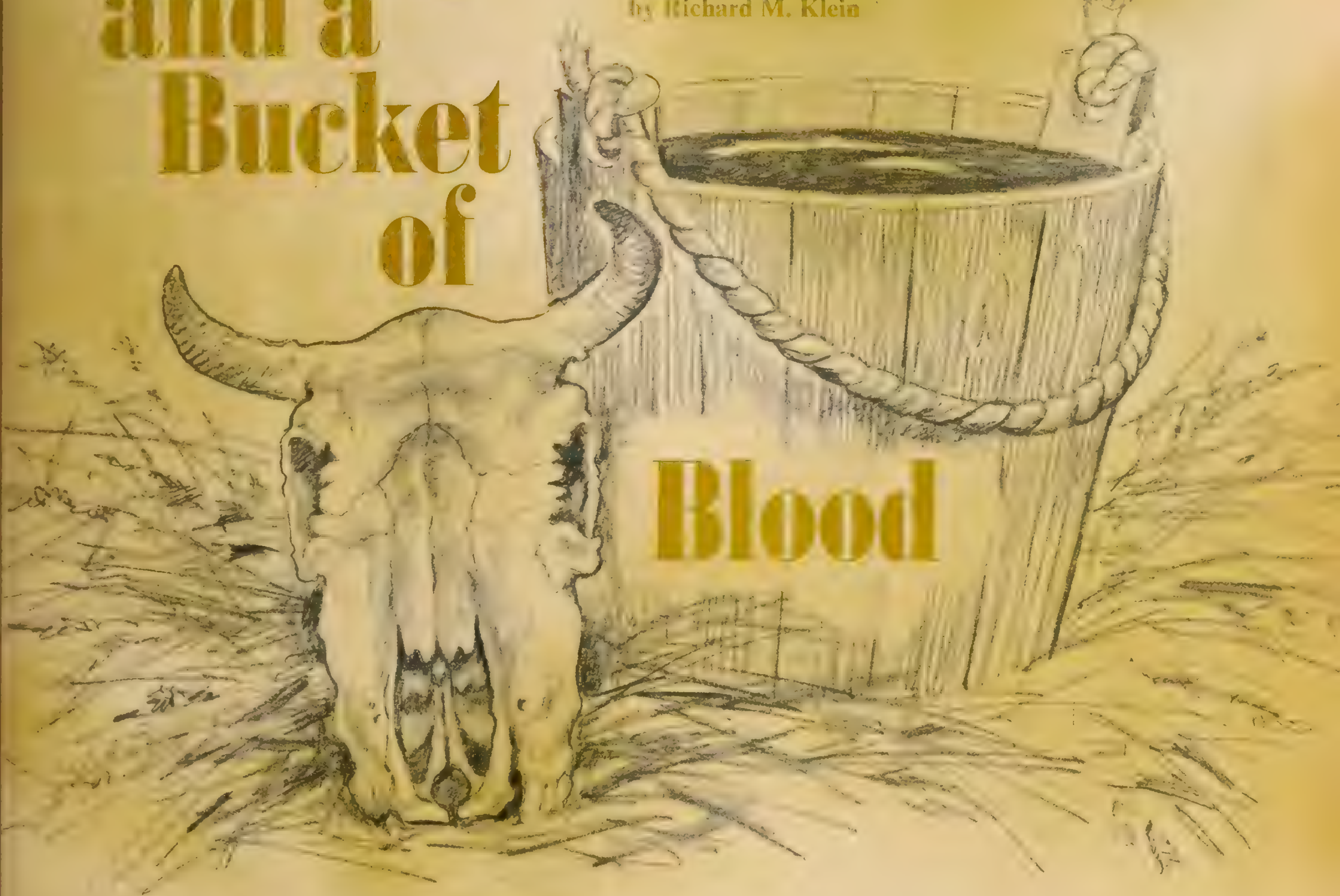


3 Just before dawn you will be looking at the half of the sky that you could not see at dusk. Where will you look to see Orion's Belt at dawn? Will you be able to see Arcturus at dawn?

Hay Hay Hay and a Bucket of Blood

Why did the farmer's cow begin bleeding to death after eating spoiled hay? When a scientist answered this question, he also found a way to save human lives and to kill rats!

by Richard M. Klein



■ Mr. Ed Carlson was a very worried dairy farmer. The Wisconsin winter of 1932-1933 had been a hard one and Mr. Carlson was forced to feed his herd on spoiled clover hay. In December two of his young cows died. Then on New Year's Day one of his favorite old cows bled to death from a small cut. In early February 1933, two more cows bled to death and Mr. Carlson saw that his prize bull was bleeding from the nose.

With a blizzard raging outside, and the temperature around zero, Mr. Carlsòn loaded his truck with one of the dead cows, a hundred pounds of the clover hay, and several milk cans of blood from a cow that had just died. He drove almost 200 miles to Madison, Wisconsin, hoping that the State Veterinarian at the University of Wisconsin could tell him how to save the rest of his cows.

Purely by chance, he stopped at the Biochemistry Building and met Professor Karl Paul Link. Dr. Link knew of this mysterious clover disease from his earlier days in Minnesota. He told Mr. Carlson that the only thing to do was to stop feeding his cows spoiled hay and, if possible, to give blood transfusions to the cows that were still alive.

When Dr. Link went back to his laboratory, he suddenly noticed that the cow's blood in the cans was still liquid. Now, if you cut your finger, blood will run out for a few minutes and then the bleeding will stop because a

(Continued on the next page)

Dr. Richard M. Klein is Caspary Curator of Plant Physiology at the New York Botanical Garden.

This photo, taken in 1944, shows Dr. Karl Paul Link working in his laboratory at the University of Wisconsin. It was in this lab that Dr. Link first began investigating the strange sweet clover disease of cattle.

Hay, Hay, Hay (continued)

clot forms. If blood didn't clot, simple cuts would bleed until an animal died.

The fact that the blood in the cans had not clotted was very puzzling. Of course, this explained how the cows died. But what was in the clover hay that kept blood from clotting? Dr. Link decided that he was going to find out.

The Long Search

Dr. Link was helped by his students and many biochemists. It was a long, hard, expensive search. Clover hay is made of thousands of different chemicals. Separating these chemicals from one another took many months. Each chemical had to be tested to see if it was the one that prevented clotting. As each chemical was taken from the hay, a small amount was mixed with rabbit blood. If the blood failed to clot, the scientist knew he was on the right track. During the next six years, thousands of tests were run.

On the night of June 28, 1939, Dr. H. A. Campbell, one of Dr. Link's co-workers, got a few crystals of a chemical that prevented clotting. The chemical, now called *Dicumarol,* had been found at last.

Wasting no time, scientists at the Wisconsin laboratory began working on huge amounts of spoiled hay. After 18 months they had almost two grams of Dicumarol. They discovered how Dicumarol is formed in clover. As clover spoils, a chemical compound called *coumarin* is changed to the anti-blood clot compound Dicumarol. The "parent" compound, coumarin, is the one that you smell when the grass has just been cut or when clover fields are mowed.

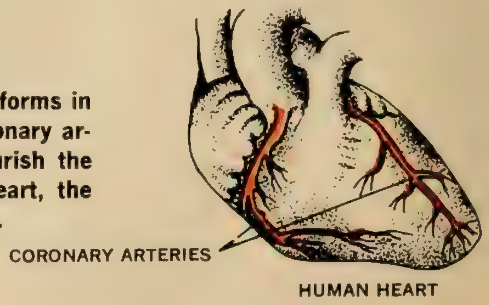
Dr. Link and his co-workers realized that Dicumarol might be very useful. First there was the problem of how to prevent the sweet clover bleeding disease in cattle. Dr. Link and other scientists found that Vitamin K, given when the first signs of the disease are noticed, will stop the bleeding and save the life of the animal. Although nothing could have been done in 1933 to save Mr. Carlson's cows, by 1940 the sweet clover bleeding disease was no longer a worry to farmers.

Another Job for Dicumarol?

We usually think of blood clots forming outside the body, on a cut or other wound. But blood can also clot inside veins or arteries, or even within the heart itself. If the clot forms in a main artery of a leg or an arm, the toes or fingers cannot get enough blood, they swell, and a disease called *gangrene* can set in. This can result in the loss of the limb.

If a small piece of a clot breaks loose and travels through the blood stream it can block the supply of blood to the brain, or the lungs, or even the heart. Sometimes the patient dies. Suppose, however, a doctor could inject something into the blood stream that would keep blood from clotting in the body? Could Dicumarol do this job?

Heart specialists in Wisconsin, at the Mayo Clinic in Minnesota, and at Cornell Medical College in New York City, read about Dr. Link's work and decided to try Dicumarol. At the Mayo Clinic alone, 73 lives were saved and over 200 patients were helped in the first tests of Dicumarol. The group of doctors in New York were studying *coronary thrombosis,* an illness caused by the formation of a blood clot in the arteries leading into the heart *(see diagram).* They found that Dicumarol was more effective and easier to use than the other remedies they had tried. Since Dr. Link had shown that Vitamin K will stop the action of Dicumarol, doctors knew that they could control the anti-



If a blood clot forms in one of the coronary arteries that nourish the walls of the heart, the heart may stop.

clotting effects of Dicumarol if they had to.

Probably the most famous case of coronary thrombosis was that of former President Eisenhower. While on a vacation in the West in September 1955, he had a coronary thrombosis and was rushed to Fitzsimons Army Hospital in Denver, Colorado. One of the compounds used to save the President's life was a Dicumarol-type, made in Dr. Link's laboratory.

You might think that the saving of the lives of many people would be a fitting end to this story. Dr. Link's interest in the blood of a dead cow paid off handsomely in curing an animal disease and in curing many thousands of people. But the story doesn't end there.

To Kill a Rat

In 1945, Dr. Link became ill with tuberculosis. He went to a sanitorium to recover. To keep his mind occupied, he became interested in reading about rats and the problems of trying to control them. There are probably about as many rats in this country as there are people. They eat or destroy millions of pounds of food. They also carry the fleas that transmit typhus fever, and carry many other diseases fatal to man. Dr. Link began to wonder if any of the compounds he had been working with might be useful as a rat poison.

Dr. Link and his co-workers had tested Dicumarol on rats, but the food grains and green vegetables that rats eat have enough Vitamin K to prevent any bleeding disease. Nevertheless, he decided that Dicumarol-type compounds as rat-killers might be worth re-investigating.

From his reading, Dr. Link discovered that rats are very clever animals. They have official "tasters" that eat a new food supply first. If the taster doesn't become sick, the other rats will then eat the food. Dr. Link reasoned that a good rat poison should be slow-acting so that the tasters would not die before the rest of the rats started to feed. Also, the poison should not keep the rats from feeding, and it must not be poisonous to humans.

One of the Dicumarol-type compounds, Compound 45, looked promising. In the laboratory, small doses of Compound 45 could be fed to rats for days and the rats would continue to eat food treated with it. After five days they began to die from bleeding inside their bodies. Even then they ate poisoned food. Now Dr. Link decided to test Compound 45 at a rat-infested farm near his laboratory.

He mixed the chemical with many different foods and found that yellow corn meal was gobbled up by the rats. Each night, the rats came to the pots of poisoned corn meal and ate. By about the fourth night, the rats came as usual, but they moved slowly. By the sixth night, all of them were dead. The entire farm and parts of the surrounding farms were completely free of rats for the first time since the area was settled.

To develop a new rat poison, Dr. Link first studied the lives of these animals. Groups of rats have "taster" rats that test a food before others in the group eat it.

A big question remained: Was Compound 45 poisonous to other animals, or to man? Rats are very common around chicken farms, so Dr. Link tested Compound 45 on his own chickens. For many weeks he fed his roosters enough poison to kill hundreds of rats. Not one chicken took sick. Dr. Link even ate the chickens and found that Compound 45 had no effect on him. Later, in fact, several people ate the rat poison by mistake and didn't even get a stomach ache.

If the poison is used properly, it wipes out rats almost completely. Today, a form of the poison can be put into the water that rats drink. Rat control is even easier—they can now eat *or* drink themselves to death.

A good share of the money needed to pay for the experiments on Dicumarol and Dicumarol-type drugs was supplied by the University of Wisconsin Alumni Research Foundation. Dr. Link used some of the letters from the name of this organization to make a name for the rat poison—*Warfarin*. You will find this name on the labels of many kinds of rat poison.

The story started with hay and blood, moved into the laboratory for chemical work, from there into hospitals, and finally into rat-infested farms. Cattle have been saved from the sweet-clover bleeding disease, the lives of the President of the United States and many other people have been saved, and rats are being kept from spreading diseases and from eating food. Behind it all was a scientist who believed that, "When you are attempting to do mankind some good, fate will be on your side." ■

With bark, nuts, onions, leaves, flowers, and other plant materials you can make many dyes of pleasing colors.

how to dye like an indian

by Winifred H. Scheib

■ Think how dull life would be if our clothes and all things made of cloth that we use were the same drab color. They would be if it were not for dyes. From the beginning of history, people have looked for things near at hand that could be used to give pleasing colors to fabrics.

When explorers came to the New World, they found American Indians using berries, bark, roots, and nuts to make dyes. In the same way, you can make dyes of different colors from plants in your yard, or from fruits and vegetables in your kitchen, and find out how the dyes work on different kinds of fabric.

Equipment You Will Need

Since you will have to boil the plants and other materials to get the color out of them, you will need a small saucepan. This pan should be glass or enamelware, because metal may cause the wrong kind of chemical reaction. For fabrics to test the dyes on, you might try cotton, silk, and wool. You can get a piece of white cotton from an old sheet, and pieces of white silk and wool should not be hard to find. You can use thread or yarn made of these materials instead of fabric.

You will need a few chemicals to make a *mordant.* "Mordant" comes from a Latin word that means "to bite." This substance helps the dye "bite" into the cloth and so makes the dye *fast.* That is, it stops most of the dye from running out when the cloth is washed.

A common mordant is *aluminum hydroxide,* made by putting powdered alum and ammonia in some water. You can get a few ounces of powdered alum at a drug store, and you probably have household ammonia in the kitchen.

Making and Using Your Dyes

You can gather nuts, bark, or berries, as the Indians did, or you can use colorful flowers from your garden. Remember that you will need a lot of blossoms to make a small amount of dye. Marigolds, coreopsis, and dahlias are all good. Fruits such as red grapes and blueberries make good dyes. Or you might try vegetables, such as onions or carrots, or leaves that are all the same color. While it is best to make only one dye at a time, you can speed things up by soaking a second batch of chopped or mashed material in water while you work with another dye.

Suppose you are going to begin with the skins of either Spanish or red onions, which are easy to get anywhere. Slip the brownish outer skins off several onions and chop the skins as finely as possible. Dump them in the saucepan, barely cover them with water, and put them on the stove to boil slowly for 15 or 20 minutes. If you have to add water to replace what boils away, try not to add too much. The more water you add, the weaker your dye will be.

When the cooking time is up, pour the dye through a strainer into a glass bowl to get rid of the bits and pieces of onion skin. Then pour the dye back into the saucepan. Now you are ready to dye a small piece of wool cloth; a square of about three inches will do. Place the cloth in the dye and put the pan back on the stove. Boil the dye for 15 minutes, stirring with a stick to spread the color evenly through the cloth. Then take the cloth out of the dye and spread it on a paper towel to dry.

Dye squares of silk and cotton in the same way. Which fabric is colored most by the dye? Cotton is a *vegetable fiber,* because it comes from a plant. Silk comes from the silkworm and wool from a sheep's hair, so both are *animal fibers*. Do you think that animal fibers or vegetable fibers are easier to color with dyes made from plants?

Making and Using the Mordant

To make the mordant, put half a teaspoonful of powdered alum in a glass jar and stir in one measuring cup (8 ounces) of water. Now add a teaspoonful of clear household ammonia, which will make the water cloudy. (Ammonia is strong-smelling stuff, so keep it away from your nose and eyes.) Soon, the ammonia and the alum combine into a jelly-like substance—aluminum hydroxide.

If you soak an undyed square of cloth in this mixture, some of the gel gets trapped in the fibers of the cloth. When you dye the cloth, the dye will be trapped in the gel. Soak a sample of each kind of cloth in the mordant, and let them dry. Then dye each sample. Compare these samples with the samples you dyed without using mordant. Does the mordant have the same effect on the colors of all three kinds of cloth?

You may want to test your dyes to see how color-fast they are *(see chart)*. Expose a small patch of each dyed cloth to strong sunlight for a day or so. What happens? Another test for color-fastness is washing your sample in tap water, and in soapy water. This may set some dyes more firmly, but it will fade others, especially if the water is very hot. Does using a mordant make the dye equally color-fast in all of the fabrics?

Different mordants give different shades, or sometimes even different colors, even though you use the same dye and fabric. Another common mordant is *tannic acid*, which you can get from tea leaves or from the bark of certain trees, as the Indians did. Make a strong tea solution by letting three tea bags soak in a cup of boiling water, or boil in water the bark from some dead twigs of oak, hickory, or sumac. Try soaking squares of cloth in this mordant and letting them dry before you dye them. How do they compare in color with the samples that were soaked in aluminum hydroxide mordant before they were dyed? Can you think of any other common substances that might act as a mordant? Try them and see.

Vegetable dyes are still in use, but today most commercial dyes are made of chemicals that are found in sticky, black coal tar. You might buy a packet of a coal-tar dye called RIT in a drug store, and try it out on different fabrics. Is it more color-fast than your vegetable dyes?

See how many different colors of dye you can make from plants, flowers, fruits, and vegetables. That's how the Indians learned to dye ■

INVESTIGATION

Many fabrics in common use today are woven of man-made fibers. Rayon fiber, for example, is made of a chemical obtained from wood. Fibers such as nylon are called *synthetic* fibers, because they are made by *synthesizing*, or combining, chemicals obtained from coal, oil, and natural gas. Does rayon fabric dye more like a vegetable fiber or an animal fiber? How about nylon?

A chart like this will help you compare the effects of a dye, mordant, and color-fast tests on different fabrics. When the sample is dry, cut off a small square and attach it with sticky tape in the proper space on the chart.

		SOURCE OF DYE: Spanish onion skins			TYPE OF MORDANT: Aluminum hydroxide		
TYPE OF FABRIC	UNDYED FABRIC	DYED WITHOUT MORDANT	after exposure to bright sun	after washing in hot water	DYED WITH MORDANT	after exposure to bright sun	after washing in hot water
COTTON							
WOOL							
SILK							

HOW IT WORKS

Speedometer

■ You are riding in a car that moves six feet each time the wheels go around, and you know that the wheels are going around 440 times a minute. Can you figure out how fast the car is going in miles per hour?

You don't have to, of course, because the car's speedometer is a computer that shows you the speed of the car at each instant. Here is how it works.

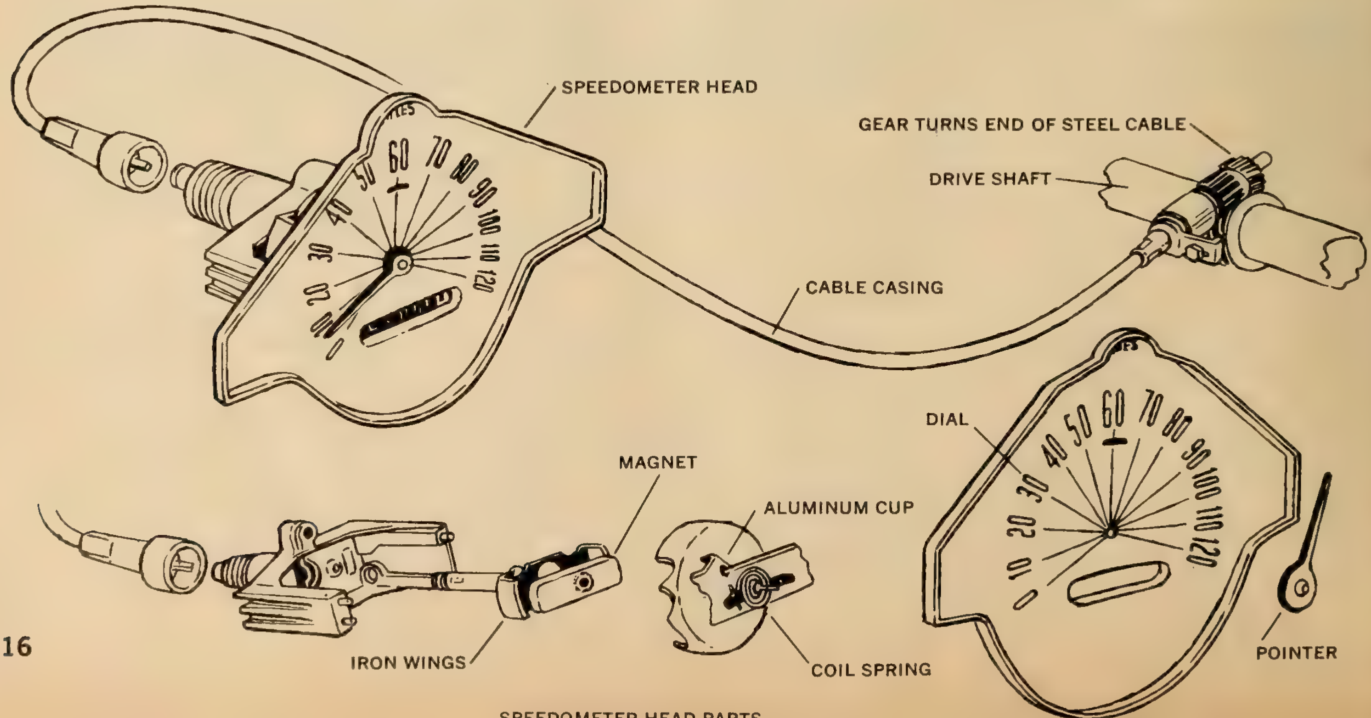
A gear on the shaft that drives the car wheels turns another gear on the end of a steel cable *(see diagram)*. As the shaft turns, the cable spins around inside a flexible metal casing. The cable runs through this casing to the back of the speedometer. There, the end of the cable is attached to an ordinary bar magnet so that the magnet spins around whenever the car wheels are turning.

The magnet is inside an aluminum cup, and a thin shaft connects the cup to the *pointer (see diagram)*. A coil spring holds the cup and shaft so that the pointer is at 0 on the speedometer dial when the car is stopped. But when its wheels turn, the magnet begins to spin, and the cup turns a fraction of an inch or so in the same direction as the magnet. This moves the pointer to, say, 10 on the speedometer dial. The faster the magnet spins, the farther the cup turns. But when the magnet slows down, the cup turns back in the opposite direction, moving the pointer to a lower number on the speedometer dial.

Since a magnet does not attract aluminum, and the bar magnet does not touch the cup, you may wonder what makes the cup move. Aluminum, like all other substances, has tiny particles in it called *electrons*. These electrons are moved around inside the aluminum by the pull of the spinning bar magnet. This movement of electrons is an *electric current*. And this current makes the cup act like a magnet, even though it is aluminum.

Two iron wings are attached to the bar magnet so they whirl around the cup as the bar magnet spins inside it *(see diagram)*. Because of the pull between the iron wings and the "magnetized" cup, the cup is dragged in the direction the wings are whirling, but the coil spring keeps the cup from turning very far. As the bar magnet spins faster, the current in the cup grows stronger, and the cup turns farther. When the magnet slows down, the current gets weaker, so the cup and pointer are pulled backward by the coil spring.

In this way, the speedometer uses an electric current to "imitate" the turning of the car wheels and thus compute how fast the car is moving at each instant. "Imitating" devices are also used to keep track of the speed and direction of airplanes and ships. Others are used in laboratories and factories to measure such things as how fast a liquid is flowing or how hard a press is pressing ■



SPEEDOMETER HEAD PARTS

Using This Issue...

(Continued from page 2T)

food, light, water, or whatever is needed for life by the particular species. Many individuals of each generation die before reaching the age of reproduction.

In the competition for food, water, and such, it is often the inheritable differences that determine whether an individual survives or not. Those with better ability to survive will tend to reach reproductive age, and their offspring will inherit the characteristics that enabled their parents to survive. In this way—over thousands of years and many generations—the characteristics of a whole species may change. Thus, in the example given in the article, a spider that inherited the ability to spin a web-like doormat may have been the origin of all the variety of webs that are shown in the WALL CHART.

Activity

Your class can probably still find spiders and their webs at this time of year. Collect some different spiders and put them in a separate jar. The spiders that spin orb webs will need gallon jars if they are to have enough space for their webs (or make a web frame as shown in the diagram).

Cover the jar with its top and punch a hole big enough to push insect food through. Plug this hole with cotton when not feeding the spider. One fly, cricket, or similar-sized soft-bodied insect is enough food for a week. When these insects are not available, feed the spiders mealworms (available in all seasons from most pet shops). Usually the food must be alive and moving in order to interest the spider.

Your pupils will enjoy watching the spiders spin webs and capture food. Have them see what spiders do when a non-food item is put in a web. Also see if spiders attack a dead insect that is hung from a thread and swung in front of them.

Sky Watching at Midnight

To see the stars at dusk, midnight, and just before dawn as described in this article, your pupils will have to do their sky watching sometime in the first three weeks of October. You might suggest that they ask their parents' permission to make observations at midnight and before dawn.

Speedometer

The way that a speedometer measures the speed of a car at any given instant—by imitating the turning of the car wheels with an electric current that changes strength as the wheels turn faster or slower—is worth discussing with your pupils, because so many different kinds of measuring devices work by "imitation."

A device that works this way is called an *analog computer,* because it solves a problem by "analogy." Your pupils are likely to think of computers as electronic machines that can solve problems by adding, subtracting, multiplying, and dividing many large numbers with the speed of lightning. A *digital computer,* of which there are many kinds, does just that. It gives an exact answer to the problem that has been fed into it.

Most analog computers are devices to measure such things as distance, speed, volume, or weight at any instant, even while these measurements are changing. Since the measurement of a constantly changing speed, for example, is likely to fall between marks on the speedometer dial, the speed cannot be measured quite as exactly this way as it can by measuring the exact time it takes a car to travel a given distance. But the latter method gives only the average speed of the car—not the speed at each instant along the way.

Suggestions for Classroom Use

You might ask your pupils to look for, and think of, as many examples as they can of instruments that measure something by imitating it. An excellent example is the thermometer. As the temperature goes up or down, the mercury or alcohol in a thermometer tube expands or contracts, imitating the increasing or decreasing energy of molecules in the surrounding air. In this way, it measures the temperature of the air at any instant.

Ask your pupils whether they can tell the *exact* temperature of the air by reading the thermometer. Could they get a *more exact* reading if there were more lines evenly spaced between the ones that are already on the thermometer scale?

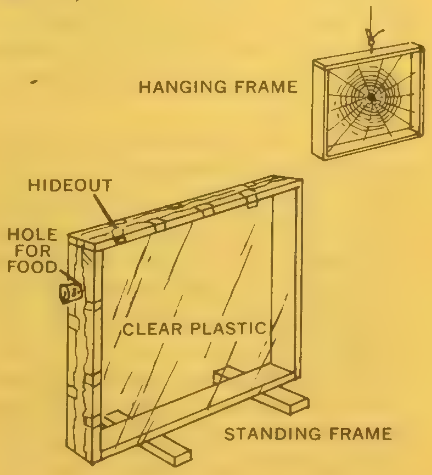
Have your pupils look at an electric or gas meter in the basement at home. Or the dial on the main floor of a building that shows where the elevator is at each instant. Or a clock! Or the mileage meter that shows how far a car has traveled. Or the gauge on the outside of a large coffee urn that shows how much water is in the urn. Or a map tracker that can be rolled along a route on a map, then rolled backwards along the mileage scale of the map to get an approximate measurement of the distance between two points on the route.

All of these devices are kinds of analog computers, and your pupils may be able to come up with many more.

Webs Spun to Order

To make a spider web frame, first you must know what size web your spider will spin. The best way to discover this is to find and measure a web, then catch its maker and build a frame of wood big enough to hold a similar web. Put crossbars on the bottom of the frame if you want to set it on a table or ledge; otherwise put a nail or screw eye in the top so the frame can be hung (perhaps from a window).

Put stiff sheets of clear plastic or glass on both sides of the frame so your spider won't escape; they can be held in place by rubber bands or tape. Put in food through a hole drilled in the side of the frame; plug the hole with a cork when not in use. Also drill a hole part way through the wood inside the frame at one upper corner to serve as a hideout for the spider. Once used to its new home, the spider will spin a new web each night (if the old webs are removed).



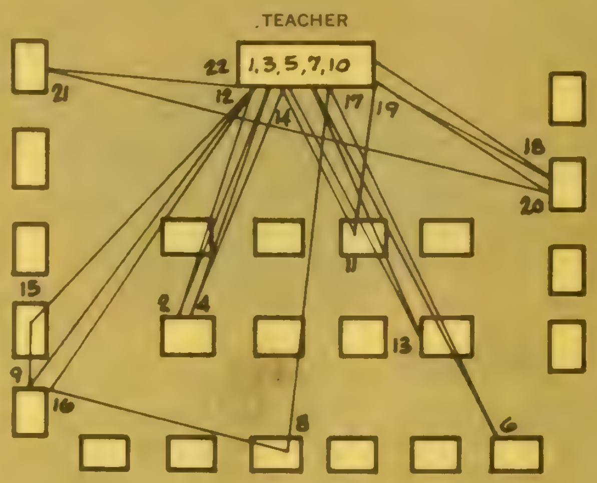


Diagram A
CHRYSANTHEMUM

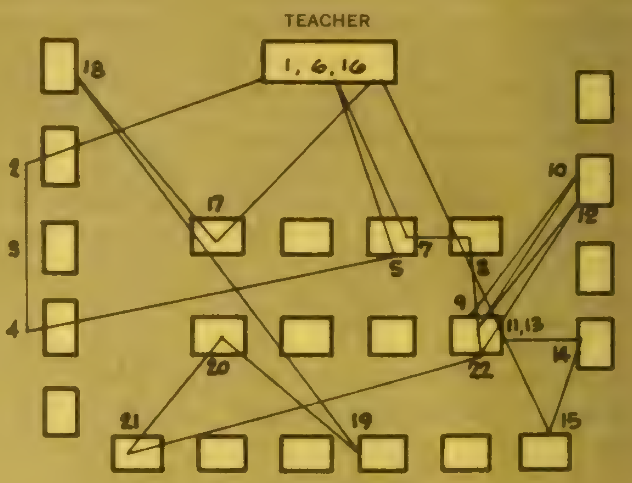


Diagram B
FLOW CHART

Do You Grow Chrysanthemums?

(continued from page 1T)

It's north here.

Leo: (Doing the same with his compass) Yeah, that's north, up is north.

Charles: How do you know which is north?

Nick: Look at the magnet (indicates needle of compass).

Ole: My blue part (of the compass needle) goes to it. That's how I can prove that it's north.

Dick: Hey! There's a magnet in there (showing the cylindrical alnico magnet placed along the earth's axis).

Leo: That's what I said before. I already told you that. Don't you listen?

Teacher: What does the thing in the globe do?

Leo: That's a pen in there—a magnetic pen. I peeked. The pointy end where you write makes the blue part of the needle come.

Dick: Hey! What's wrong with mine! My silver end goes north. This thing is no good. (Throws it down.)

Leo: It's okay, it's just backwards. You've got to think opposite with that one.

Teacher: Now what have you learned, boys?

Ole: This is a magnet (holds up magnet from inside globe). The blue part of my compass goes to it.

Leo: I found—well, I think—that in pirate days they got treasure by using a compass—they took steps and went east then west. You know . . .

Teacher: What about you, Zack?

Zack: I don't know . . .

Nick: We know where south is now because when the needle points to north, you just turn the compass around and line it up with the N on the circle and then south is underneath.

It is not hard to guess that the next lesson was a treasure hunt using clues and compasses.

Discussion II

Some other fourth grade boys had been experimenting with the kind of balance made from a wooden bar and two paper plates suspended by thread. They had used blocks of various shapes and tried to balance them in different ways.

Teacher: Richard, what did you discover, do you remember?

George (Richard's partner answers at the prompting of Richard): I made something from 18 little blocks, five triangles, one big triangle and two blocks against one sort of big block and it balanced.

Teacher: Against one sort of big block and it balanced. Right. That's very good. Did anyone else do something? Matthew, what did you do?

Matthew: We – um – put four small blocks . . .

Teacher: What do you mean by "small"? (He gestures.) About how small is that?

Matthew: About two inches.

Chorus: No, not even an inch.

Teacher: Not even an inch. (Several children get up and move to apparatus.)

Matthew: I put this here, six small blocks . . .

Teacher: Who was your partner? Hal, can you help, you were sitting over in that place.

Hal: I ain't gonna talk and I know why. (Looks at tape recorder which is on, and makes a face.)

Teacher: Jack, what did you do?

Jack: A triangle and a block balanced one big block.

Teacher: Bob, what about you?

Bob: We didn't get nothing.

Teacher: You didn't get anything. If you were working what did you find out?

Bob: Nuttin'.

Could you suggest any questions at certain points which might have turned this type of discussion into the other type? ■

(N&S *articles about approaches to science teaching are not meant to imply endorsement of any particular approach by The American Museum of Natural History.)*

nature and science

TEACHER'S EDITION

VOL. 4 NO. 3 / OCTOBER 17, 1966 / SECTION 1 OF TWO SECTIONS

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Thoughts on Sound and Hearing

(Selections from the Science Study Series book, Waves and the Ear, *by Willem A. Van Bergeijk, John R. Pierce, and Edward E. David, Jr., Anchor Books, Doubleday & Company, Inc., Garden City, N.Y. Copyright © 1960 by Educational Services Incorporated. Reprinted by permission of the publisher.)*

■ When I think about hearing, I sometimes try to imagine what I would feel, what sort of person I would be, had I been born totally deaf. I would not be able to enjoy music or speech. Only with much and arduous training would I learn to speak coherently or, for that matter, to speak at all, unless someone somehow conveyed to me by other means that there is such a thing as sound. It would be dangerous for me to venture out in the street, because I could not hear an approaching car nor the warning cry of a bystander. At least half of life would not exist for me, and the other half would be enormously complicated, even perilous.

Thoughts of this sort are rather sad and probably pointless, but they make you aware, in a negative way, of the functions of hearing. First of all, you realize that the ordinary world is full of sounds of enormous variety: Somehow they are distinguishable from one another, so much so, indeed, that we even classify them by different names. But the hum of the attic fan is not the same as the hum of the table fan, nor does your mother's tea kettle have the same whistle as your aunt's. And you know very well who is talking to whom in the next room.

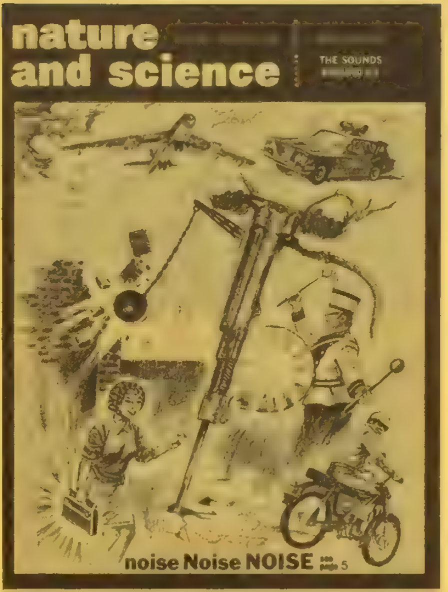
There are, therefore, smaller differences that distinguish sounds from one another, differences that do not merit classification by separate names. You can say that the attic fan has a louder hum, and that your aunt's tea kettle has a higher pitch; you can say that the neighbor's lawn mower putt-putts faster than yours. But how do you describe the difference between Mary's and Lucy's voices?

One may be somewhat harsher, or more nasal, or of higher pitch, but there remains that indescribable something that makes Mary sound uniquely herself. Of all the people you know, how many could you not immediately identify by their voices? I think you will find very few. It is remarkable that within the limitations of the human voice such a huge variety of small differences can exist. But it is even more baffling that the ear can distinguish among them, and that the brain, receiving signals from the ear, can recognize the particular differences quite readily.

Is Listening "Simple"?

Most of the sounds reaching your ears are of little or no importance. You simply do not listen to them. *Simply?* Is it really so simple to hear the sound that, for some reason, interests you amid a host of other, often louder, sounds? Most of us are familiar with the "party situation": a room full of people all talking, shouting, and even singing at the same time. Yet you can

(Continued on the back page)



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 7T).

● Making and Changing Sound Waves
By making glasses, fishing line, and the air in bottles vibrate at different strengths and frequencies, your pupils can find out how sounds of many different kinds are made.

Noise, Noise, Noise
What is it, how does it affect us, and what can be done about it?

● The Ups and Downs of Sound Waves
This WALL CHART shows how sound waves are made and gives the frequency ranges and loudness of some common sounds.

The Not-So-Silent World
Scientists are studying the ways in which fishes, porpoises, and other water animals make and hear sounds.

Brain-Booster Contest

● Hunting with Echoes
Just how accurate is the echolocation system of bats? Here is how some biologists tried to find out.

How It Works—Tape Recorder
Your pupils will find out how sound waves are recorded in a magnetic code that can be used to reproduce the sound waves.

IN THE NEXT ISSUE

How to set up a salt water aquarium and study ocean animals . . . A picture story shows how snakes are adapted to swallow large objects . . . Measuring and studying raindrops . . . What a dentist does to fix a cavity.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Sound and Sound Waves

The articles in this special-topic issue will introduce your pupils to many aspects of the sounds around us *(see "In This Issue," page 1T).*

Suggestions for Classroom Use

Those of your pupils who like to investigate things for themselves should probably start with the Science Workshop on "Making and Changing Sound Waves." This will lead them to look for basic information about sound waves in the Wall Chart.

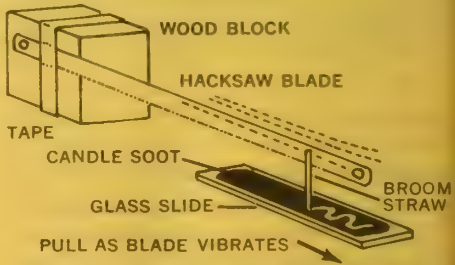
Those who are more interested in animals than in physical phenomena might better begin with the articles on bats and marine animals. For those concerned with their own immediate problems, the article on noise is the best starter.

Sound waves are not visible, but here is one way you can make them more "real" to your pupils. With the easy-to-make ripple tank and tin can oscillator described on this page, you can project on the ceiling a picture of sound waves moving through water. (It was suggested to us by Ira Taneman, Haskell Avenue Elementary School, Granada Hills, Calif.)

Your pupils can see that loud sounds make darker waves in the projection than weak sounds. (Loud sounds push more molecules of water together in each wave.) They can also see high-pitched sounds making waves faster than low-pitched sounds. They can see that the waves of different frequencies move through the water at the same speed. (Sound waves travel about 4,856 feet per second through water at 68°F—more than four times as fast as through air.)

They can see the waves bounce back from the opposite side of the dish (or from a stiff sheet of cardboard held upright in the water). The returning waves pass through the waves from the tin can, creating an *interference pattern,* a kind of moiré pattern *(see* N&S, *Feb. 7, 1966).* The waves are all of the same frequency, but depending on which parts of the waves meet, the outgoing and returning waves reinforce each other (dark spots in the pattern) or cancel each other (light spots in the pattern) *(see* Wall Chart).

Ask your pupils if they think the water is moving with the sound waves. Have them drop several little pieces of paper on the surface of the water to see for themselves that the water is not moving along with the sound waves.



Here is a way to show your pupils why sound waves are usually pictured as a wavy line. Tape or cement a short piece of broom straw to the end of a hacksaw blade and tape the blade to a block of wood, as shown in the diagram. Pluck the free end of the blade hard, so it makes sound waves strong enough to be heard. Then place a glass slide coated with candle soot under

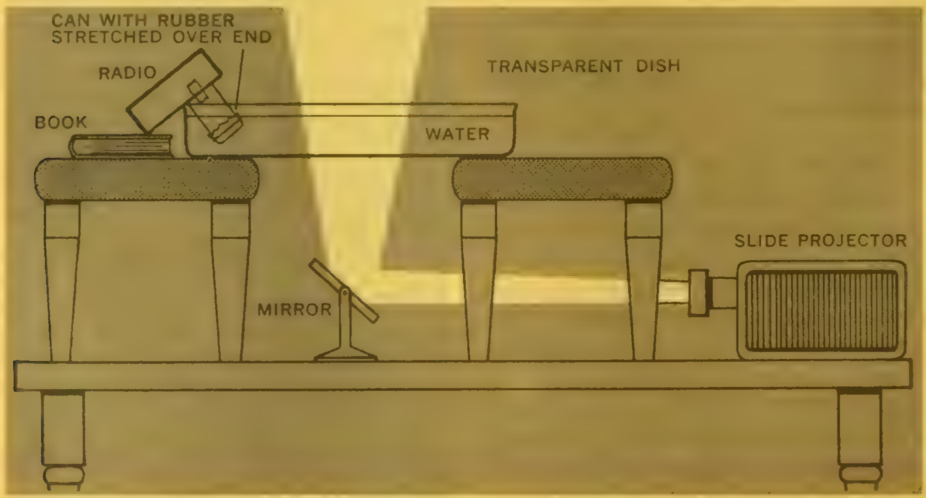
(Continued on page 7T)

How To Make a Ripple Tank and Tin Can Oscillator

To make a simple ripple tank and tin can oscillator, you will need:

Clear plastic or pyrex dish, 2" deep
slide projector
mirror about 6" across
pocket-size transistor radio
4-oz. fruit juice can, ends removed
balloon

Set the dish on two chairs *(see diagram)* and pour in about 1½ inches of water. Cut a piece of rubber from the balloon, stretch it over one end of the can, and secure it with a rubber band. Fasten the open end of the can over the loudspeaker of the radio with masking tape. Prop the radio as shown, so that the rubber-covered end of the can is in the water. Prop the mirror under the dish and shine the projector beam at the mirror so that the light is reflected through the water to the ceiling. Darken the room and turn on the radio with volume high. It may take a moment for the water to stop moving, but then you should see a projection on the ceiling of the sound waves moving through it. It works better with speech than with music, because music makes waves of many frequencies all at once.



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SPECIAL-TOPIC ISSUE

THE SOUNDS AROUND US

noise Noise NOISE

see 5

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making and changin
SOUN

How man
different sounds can you mak
with a pop bottle
Here are some ways to find ou

■ It's easier to make sounds than *not* to make them. If you don't believe it, try sitting as still as you can in a quie room. You will begin to hear yourself breathing, and maybe even hear the sound of your heart beating. Can you turn a page without making a sound? Or move a chair? Or remove a rubber band from around a package?

It's not quite so easy to make a sound that is exactly as high or low in pitch and as loud or soft as you want it to be. Ask any musician. But you can find out how to make the sounds you want to by testing things such as glasses and bottles and strings that you have at home.

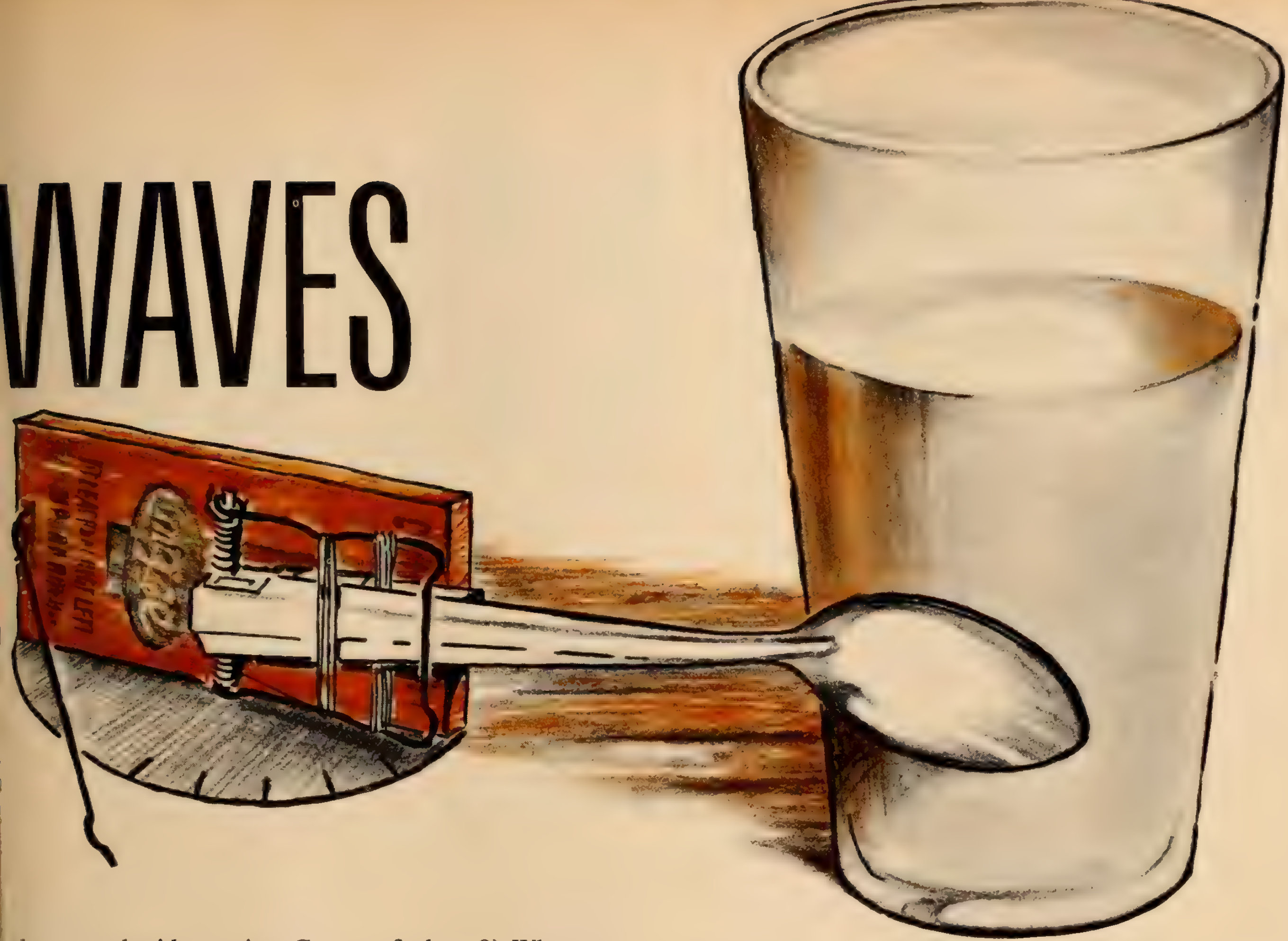
Making Waves with Waves

The WALL CHART in the center of this magazine shows how pressure waves are sent through the air by anything that is moving. Waving your hand makes such waves in the air, but they are usually too weak and too far apart for your ear to detect them. Try waving your hand back and forth very rapidly next to your ear. If you still can't hear a sound, try holding a small book in your hand as you wave. This should make stronger waves that your ear can detect.

An object has to be moving fast enough to make at least 15 waves per second before most people can hear it (*see* WALL CHART). To move that fast, it must usually be vibrating, or moving rapidly back and forth through a short distance. Can you think of some ways to make a drinking glass vibrate? How about a piece of fishing line? Or the air in a bottle?

The easiest way to make a glass vibrate is to tap it with something, say a key or spoon. (There are at least two

WAVES



ther ways beside tapping. Can you find one?) When you ap the glass, listen carefully to the sound it makes. You an hear it change from loud to soft, then stop. Does it hange in pitch—that is, does the sound get higher or lower s it dies out?

Tap the glass several times, waiting each time until the ound stops. How do the sounds compare in pitch, loud- ess, and length? Do you think the differences might be aused by the way you tap the glass?

easuring Your Taps

One way to find out is to make a spring-tapper, so you an tell how hard you are tapping. You can make one by ttaching a spoon to a mouse trap, as shown in the dia- ram on this page. First make weak, medium, and strong aps, listening for differences in loudness. Then do the ame, listening for differences in pitch. And again, for differences in how long the sound lasts. Can you tell from our findings how the strength of a tap affects the sound ou hear?

The closer the glass is to your ear, the louder the sound ou hear (*see* WALL CHART). You can check this by hav- ng a friend give the glass taps of equal strength at different istances from your ear. Do you hear any differences in e pitch of the sound when the glass is tapped near your ar and farther away from it?

Measure your taps with this spring-tapper. Wire a spoon to a mouse trap and cement a piece of cardboard to the base, as shown. Hold the trap with the spoon just touching the glass, pull back the spoon to the proper line, and let go.

Scientists have found that when a tuning fork vibrates close to a person's ear, he usually hears a sound of lower pitch than when the fork is vibrating farther away. The fork always makes sound waves at the same *frequency* (*see* WALL CHART). But when the fork is close, the waves that reach the ear are stronger than when the fork is farther away. The stronger waves seem to affect the signal that your ear sends to your brain, making you hear a sound of lower frequency—as if fewer sound waves were reaching your ear each second.

Does Water Make Sound Grow or Shrink?

Can you think of other ways to change the sound you hear when you tap the glass? Try tapping it with a piece of wood, or plastic, or the eraser end of a pencil. Set the glass on a newspaper, a plate, or a cookie pan before you tap it. Hold your finger against the glass. Do any of these things make the glass vibrate any faster, or farther, or longer? (Do they make any of the things touching the

(Continued on the next page)

INVESTIGATION

Do you think that a heavy liquid in a glass will make a lower sound than a lighter liquid? You can find out by pouring water into a large glass or jar and stirring two or three tablespoons of salt into the water. Keep hitting the sides of the glass with your spoon. Notice how the pitch of the sounds changes when you first put in the salt, and then as it dissolves in the water. What happens if you use baking soda, or sand, instead of salt? Can you explain why putting different things into water makes it vibrate at different speeds?

glass vibrate?) You should be able to tell by the sounds you hear.

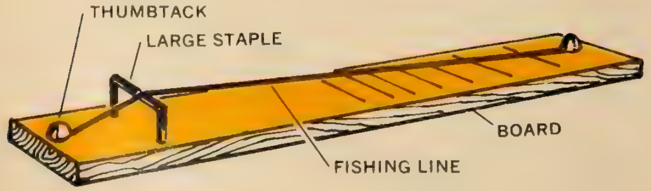
Pour a little water into the glass and tap it with your spring-tapper. Pour some more water in and tap it again, just as hard as before. How does the water in the glass change the waves it makes and the sounds you hear? Do you think the water vibrates with the glass?

If you have a piano, or some other musical instrument, see if you can make a sound with it that is the same pitch as the sound made by tapping the glass. You might have to pour some water in or out of the glass to match the sounds as closely as possible. Even if you match the pitch and loudness of the sounds, though, they won't sound exactly alike. Can you guess why?

When you press a piano key, it makes a little hammer tap one or more steel wires that are tightly stretched between posts on the piano frame. If you get a chance, open the top of a piano and find the wires that are tapped when you strike different keys. See what you can find out about the length and thickness of the wires that make sounds of different pitch. Can you guess why the wires that make the lowest notes have wire wrapped around them?

A guitar or banjo has tightly stretched wires, too, but not nearly as many as a piano. You make these wires vibrate by pulling, or "plucking," them, instead of tapping.

You can make a simple one-string instrument with a piece of wood, two thumbtacks, a piece of fishing line, and a large metal staple (*see diagram*). Give the string a weak pull, then a stronger one. Pluck it with the string stretched very tight, then not so tight. "Shorten" the string by pressing the long end against the board at different places with your finger as you pluck it. How do these changes affect the vibrations of the string?



Wind and Waves

You can make sounds with an empty pop bottle, either by tapping it or blowing across the opening—but they aren't the same. Try it, then pour some water in and try it again. Can you figure out why adding the water made one sound go down in pitch and the other go up? (Hint: Tapping makes the bottle and the water vibrate; blowing makes the air in the bottle vibrate.)

A whistle that you blow works the same way. And if it has a sliding rod inside, or some holes in the tube, you can change the length of the air column in the whistle to make sounds of different pitch. To whistle louder, blow harder.

These are just a few of the ways that you can make and change sounds. Another way is described in "How It Works—Tape Recorder" in this issue. The investigation below suggests some things you can do to find out about the sounds made by vibrating things, and you can probably think of still more ■

INVESTIGATION

You can make a sound of the same pitch and loudness with just about any musical instrument. Yet the same note has a different quality, or *tone*, when made by different kinds of instruments, say a piano, a violin, and a trumpet. You can get an idea of why this is so by tapping different things in your home with a spring-tapper.

Tap pans, for example. Do large pans make different noises than small ones made of the same metal? Tap pans made of aluminum, cast iron, and stainless steel. Tap blocks of wood of various sizes. Tap metal cans, glass jars, and cereal boxes—before they are opened, when they are partly filled, and when they are empty. Tap wooden and metal boxes—open and closed, empty and full. Tap lampshades and cushions. (Can you find something that makes no sound at all when tapped?) By testing such things, you can find out how size and shape and the materials things are made of affect the sounds they make when they vibrate.

If you would like to find out more about sounds and sound waves after reading this issue, you might look in your library or bookstore for these books: **Sound: An Experiment Book,** by Marian E. Baer, Holiday House, New York, N.Y., 1952, $2.50; **The Magic of Sound,** by Larry Kettlekamp, William Morrow & Co., Inc., New York, 1956, $2.78; **The First Book of Sound,** by David E. Knight, Franklin Watts, Inc., New York, 1960, $2.50. **Sound and Hearing,** by S. S. Stevens, Fred Warshofsky, and the editors of Life, (Life Science Library) is written for adults, but it has many fascinating illustrations. Look for it in your public library.

NOISE NOISE NOISE

The sounds we make may please us.
The sounds that others make
Can bother or displease us,
Or make our eardrums ache.

Or, to update an old saying—
One man's music is another man's noise.

■ When people talk about "air pollution," they usually mean the dirt and irritating gases that fill the air around so many of our cities. But the air around us is full of another kind of pollution *(see cover)* that can bother us more than dirt and gases, even though it is not as dangerous to our health.

Sounds fill the air in most of our cities and often in our homes, schools, offices, and factories. If a sound is something you want to hear, say a song or a call from a friend, then it is just a sound. But if you are trying to sleep or study, a sound like that becomes a *noise.*

What Makes a Sound a Noise?

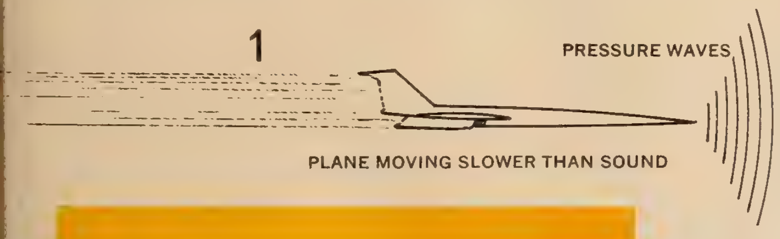
There are sounds that everyone thinks of as noise—the sharp rattle of a road worker's air chisel, for example, or the screech of a train's wheels rubbing against the rails. Such sounds can make your ears hurt. But in general, a noise is simply sound that you don't want to hear.

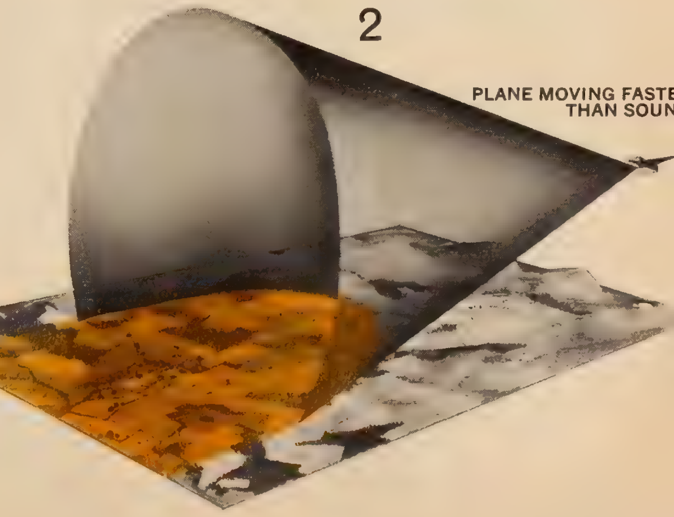
Noise is not all bad, of course. You may not like to hear the blare of an auto horn as you cross the street, but it warns you to move out of the car's path. Rattles or thumps from a car engine warn you that something needs to be repaired. And sometimes one noise can help to cover up, or cancel out, another noise *(see "The Ups and Downs of Sound Waves").*

Still, with more people living close to each other than ever before, with more autos and motorcycles, radios and TV sets, dishwashers and air conditioners, jet planes and power mowers, the world is getting noisier all the time.

One of the newest—and loudest—noisemakers is the supersonic airplane. When it is flying at the speed of sound or faster, it makes a sound wave heard by people on the ground below as a sharp *boom (see diagram).* Two years ago, the U.S. Government made tests in Oklahoma City, Oklahoma, to find out how people felt about this noise. Within six months, Air Force jets produced more than 1,200 sonic booms over the area. At the end of the test, about 25 per cent of the people living there said they could not "learn to live" with the noise. They said the booms startled them and interrupted their sleep. As a

(Continued on the next page)





An airplane pushes against the air in front of it, making pressure waves that are usually too weak and too low in frequency for your ears to detect them *(Diagram 1).* If the plane is flying slower than sound can travel through the air, these waves move ahead faster than the plane. But if the plane is flying faster than sound, the waves pile up in a strong *shock* wave that sweeps back from the plane in a giant cone *(Diagram 2).* People on the ground in the path of this wave hear the thunder-like clap called sonic boom.

result, engineers are trying to find ways to reduce the sonic boom from supersonic passenger planes that are now being designed.

Measuring a Noise

Just how "noisy" are the noises around us? Psychologists are trying to measure noisiness, and are not finding it an easy job. The trouble is that the same noise affects everyone differently. To one man, the sound of cars passing by is a soothing background whisper; to another it is an unbearable noise. It's easy to measure the loudness of a sound, but it's not easy to measure how different kinds of sound affect the human ear.

For one thing, sounds of the same strength, or *intensity,* are not equally noisy *(see "The Ups and Downs of Sound Waves").* Scientists know that high-pitched sounds and low-pitched sounds do not seem as loud to the human ear as sounds in the middle frequencies. They know too that people are more sensitive to high sounds than to low sounds. And, of course, sounds have different "meanings" to different people—or even to one person at different times. A baby's cry may be just as loud as the wail of a distant ambulance siren, but one may disturb you while the other does not.

Tests show that the longer a noise lasts, the more annoying it is to most persons. And a sound that you don't expect to hear—the slam of a door or backfire of a truck—usually seems noisier than one that you expect, even though the unexpected sound is no louder. Finally, when a noise that continues at the same pitch is louder than the surrounding sounds—like the hum in an old radio—it seems to be more annoying than if the noise is a mixture of sounds at many different pitches.

So far scientists have been unable to develop any way of measuring noise that takes all of these things into consideration. However, one system that is often used measures the loudness of sounds at different *frequencies*, so the measurement can be made to take into account the greater sensitivity of our ears to noises of certain pitches.

What Noise Does to People

There is still some question about how noise affects people's actions. Scientists know enough about sound and the human ear to know which noises will cause real damage. Very loud noises can cause deafness that may last hours or even days, and exposure to loud noises over long periods can make some people permanently deaf.

A Canadian scientist, Dr. Claude Fortier, did an experiment to see how loud noises affected rats. He put rats in a soundproof room where sirens blasted so loud he could not stand it himself. He used mirrors to watch from outside the room. Dr. Fortier turned the sirens on for 30 seconds, then off for 30 seconds, and kept doing this for about 5 minutes. He used hundreds of rats in the year he did the experiments. The sounds affected the rats' nerves so that two-thirds of the animals stiffened up as if they were frozen. The rest ran around in circles and many developed open sores, called *ulcers,* in their stomachs.

Most factory superintendents are now careful to control the noise levels in their plants. Ear plugs are provided for workers who are regularly exposed to noise that could affect their hearing. The workers also take regular

In our crowded cities, automobile engines and horns often make so much noise that you can't hear a friend's words.

TAXI
TAXI
PLYMOUTH

To these girls, making noise is a "ceremony" that you are expected to perform when you hear, say, the Beatles.

hearing tests so that those who are more sensitive to noise can be given jobs in quieter areas.

It is much harder to tell how faint noises affect the way people work. Some studies have shown that noise makes human muscles tighten up and puts a strain on the nerves. Typists, for example, used 14 per cent more energy working in a noisy room than in a quiet one, even after they got used to the noise. Investigators at Bellevue Hospital in New York found that the noise from popping a blown-up paper bag could cause blood pressure in the brain to increase, even if the person was expecting the explosion. But there is still no definite proof that noise seriously affects the way people do their jobs. Women work just as well in noisy factories as in quiet ones, although they may be more irritable and tired at the end of the day.

Toward a Quieter World

Engineers, scientists, and lawmakers are trying to make our world quieter—a little bit, at least. New York City has laws limiting the loudness of radios, TV sets, record players, and musical instruments between 11 P.M. and 7 A.M. Moscow, Paris, and Memphis, Tennessee have tried bans on horn blowing. Some cities in Britain forbid people to ride motorcycles during sleeping hours. The U.S. Government is trying to pass a law that will make airplanes meet certain noise requirements.

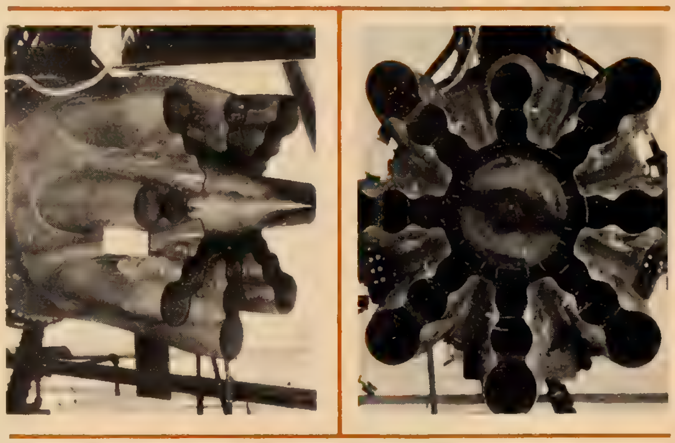
Sometimes noise can be softened, or *damped,* at the source. For example, the muffler on an auto's exhaust pipe gives the exhaust gases a chance to spread out a little before they are shot out into the air. Because of this, the gases make weaker sound waves than if they were piped directly from the motor into the air. Usually, a muffler reduces an engine's power. However, sending a jet engine's exhaust gases into the air through 21 small openings instead of one large one cuts much noise and only reduces the engine's power by 1/50th (*see photo*).

Another way to keep noise down at the source is to set a typewriter or other machine on felt or rubber pads. Such pads keep the table or floor from vibrating along with the machine and making noise as they vibrate.

Another way to reduce noise is to soak it up. When sound waves bounce off the walls and ceiling of a room, their echoes add to the new sounds in the room and make a jumble of noise. A ceiling made of *acoustical tile,* which has many tiny holes in it, soaks up sound waves like a sponge soaks up water.

Some noises can be *masked,* or covered up, so that you don't notice them. The music that you sometimes hear in a restaurant or elevator makes the noise of many people talking at once less noticeable.

Noise can also be *blocked,* or stopped completely. That might seem like the easiest way to deal with noise, but it isn't always so. If you are talking in a room, it takes an airtight brick wall about four inches thick to keep your words from being heard in the room next door. The inside walls of most houses and apartments built today are much thinner than that, and are made of lighter materials than brick. This adds to our noise problems.



This jet engine nozzle, shown from the side and the rear, makes the exhaust gases go into the air in a number of small streams instead of one large one. This reduces the noise without reducing the engine's power very much.

Too Little Noise?

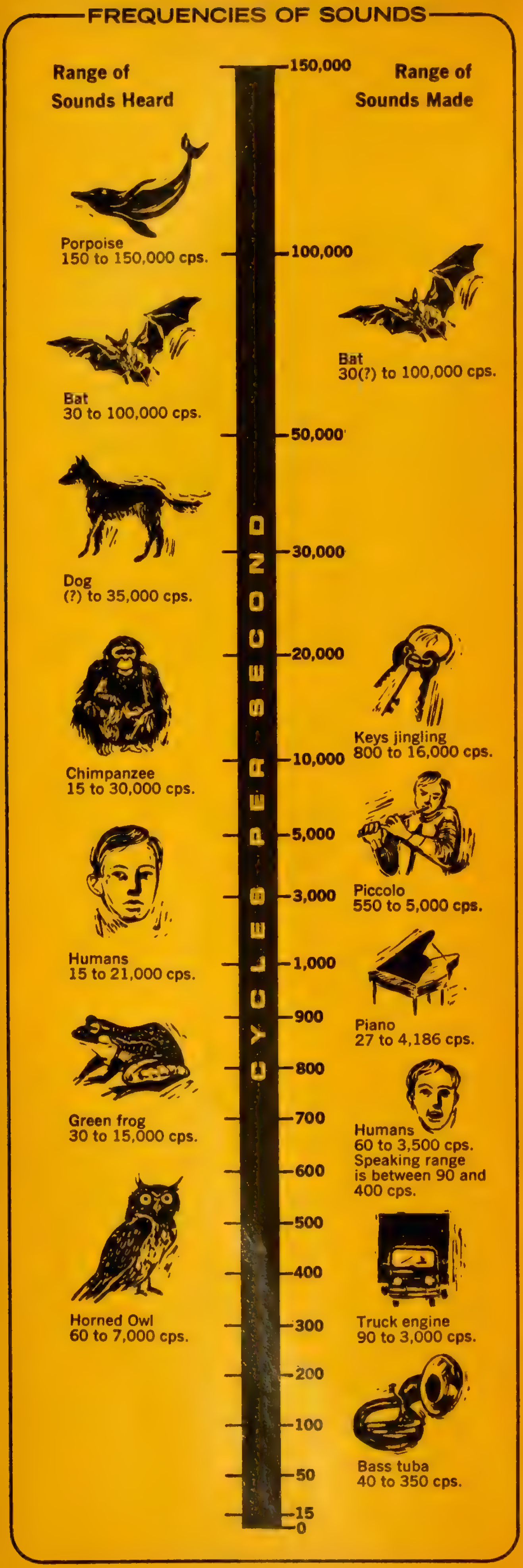
But blocking out all outside sounds from a room causes a different noise problem. This was done in the reading room of a new college library, and the room was so quiet that the sound of a reader turning a page or pushing back his chair disturbed the other readers. Scientists found that the students could actually study better if they heard a small amount of the outside noise they were used to.

If you want to help reduce the "noise pollution" in the air of your home, schoolroom, or city, keep in mind that noise is simply a *sound that someone doesn't want to hear*—and act accordingly. To avoid noise, try using earplugs ■

Making Things Noisier

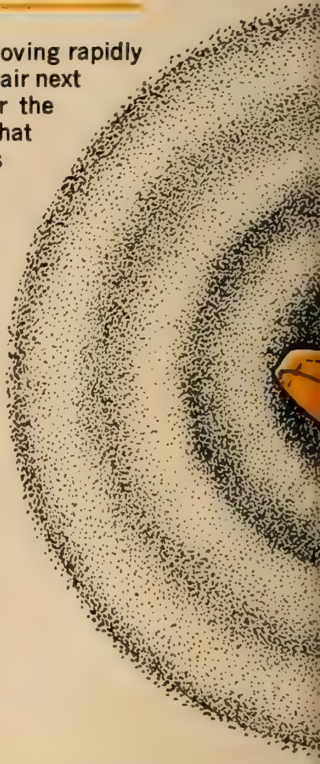
Most of the time people prefer quiet to noise—but not always. For example, the manufacturer of a power lawn mower improved the engine so that it produced the same amount of power with much less noise. But when the mower slowed or stalled in heavy grass, as all mowers do, the buyers thought it had less power than the noisier model. So the maker had to put back the noise to sell the mowers.

Can you think of some other ways that people make things noisier—and the reasons why they do it?


FREQUENCIES OF SOUNDS

The Ups and Dow

■ **Clap your hands once and you hear a "smack." The a**
is pushed out from between your hands when you bri
them together. At almost the same instant, the air in yo
ear pushes your eardrum inward, and your ear signa
your brain to give you the sensation of a smacking sour
The air your hands pushed did not travel to your e
but the "push" did. It traveled from your hands to yo



When a bell rings, the metal vibrates, moving rapidly in and out. Each outward move gives the air next to the bell a push, squeezing together the *molecules*, or tiny particles, of gases that make up the air. As the metal moves inward, these molecules spring apart and push together the molecules next to them. In this way, a sound wave moves out through the air in all directions.

The harder you strike the bell, the farther the metal moves in and out, and the stronger the push it gives the air next to it. A strong push squeezes together more molecules than a weak push, making a stronger wave. The wave slowly loses strength as it pushes its way out through the air. Also, each vibration of the bell is shorter than the one before, making each sound wave weaker than the one before it. The strength, or *intensity*, of sound waves is measured in units called *decibels (see scale at right).*

The bell always makes soun
frequency, that is, the sam
quency of sound waves is
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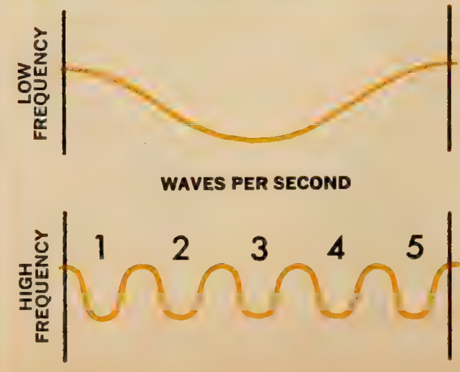
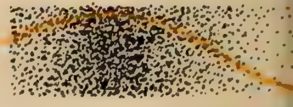
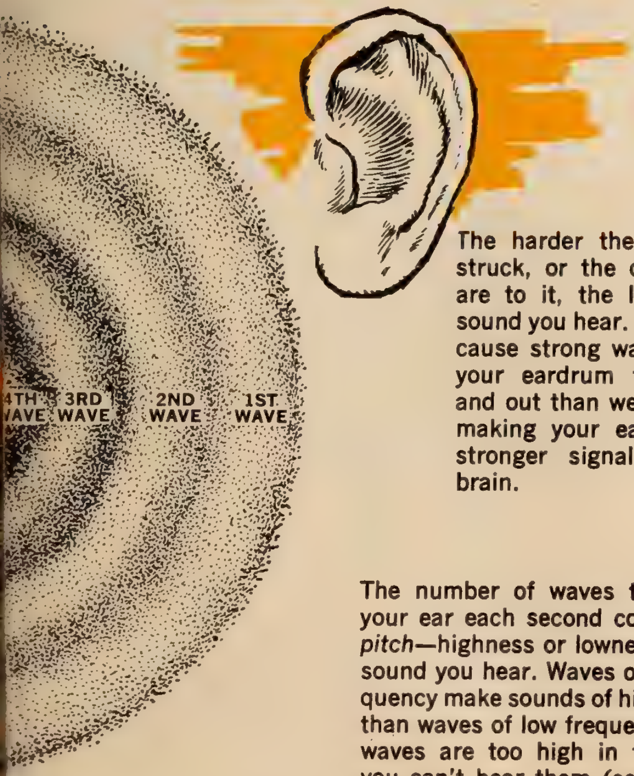




Scientists usually draw a w
line, like the side view o
water wave, to represen
sound wave. The "hill" is
part where the molecules
squeezed together; the "
ley" is the part where t
are spread apart. The hig
the hill, the stronger the wa

# of Sound Waves

at a speed of about 770 miles an hour, moving through
air like a wave moves over the surface of water. This
ve of "push" or pressure moving through the air was
ound wave.
his WALL CHART shows you how sound waves are
de and what is different about the ups and downs of
ves that make you hear different kinds of sounds ■



The harder the bell was struck, or the closer you are to it, the louder the sound you hear. This is because strong waves move your eardrum farther in and out than weak waves, making your ear send a stronger signal to your brain.

The number of waves that reach your ear each second controls the *pitch*—highness or lowness—of the sound you hear. Waves of high frequency make sounds of higher pitch than waves of low frequency. If the waves are too high in frequency, you can't hear them (*see scale at left*).

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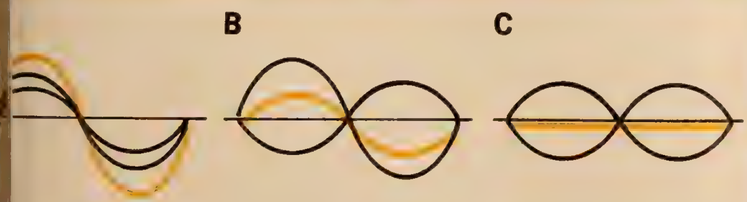
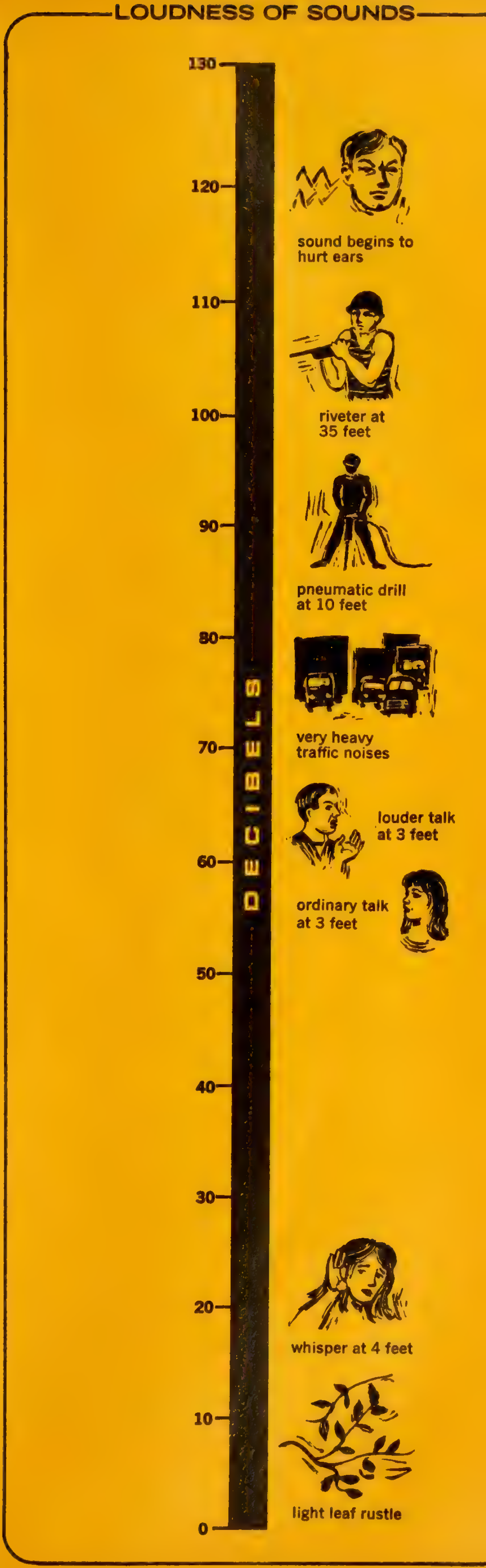
waves per second. The fre-
ured in *cycles* (waves) *per*



e two sound waves meet in the air a new wave is formed. If their
and valleys overlap, the new wave is stronger than either of the
ial waves (A). If the hill of one wave meets the valley of the other
the new wave will be weaker (B). Meeting in that way, two waves
ual strength cancel each other, so that you hear no sound at all if
re at their meeting place.



the not-so-silent world

Grunts, whistles, squeals, and clicks fill the underwater world with sound. Scientists are just beginning to discover the part that sound plays in the lives of water animals

by Edward Edelson

■ Perhaps you have heard of the book *The Silent World,* which was written by Jacques Cousteau, the famous French scientist. It describes his underwater adventures. The book is exciting, but is there silence underwater?

For many years, most people thought so. Then, during World War II, the United States Navy developed instruments to detect enemy submarines by listening to the sounds they made. The sailors who used these instruments sometimes found themselves hearing many strange sounds, none of them made by submarines. They were the sounds of fishes and other animals of the sea. Ever since, scientists have been trying to find out more about these sounds.

Humans get much of their information by seeing things. But seeing can be difficult in the sea, where little light penetrates. So sea animals often rely on hearing to learn what is happening around them. Professor N. B. Marshall of the British Museum has found that many of the fishes that swim deep in the sea, where there is no light at all, are well equipped to make and detect sounds.

Sea animals seem to make sounds for the same reasons that land animals do. Their noises attract mates, or warn other animals away from their territories—just as the songs of some birds warn away potential rivals. Members of some species of fish make sounds that warn each other of danger, or that tell about the presence of food. But the most interesting sounds are made by sea-going *mammals,* such as porpoises and whales. Many of these animals find their way around by *sonar*—sending out sounds and picking up the echoes that bounce back from obstacles.

Sea mammals also make other sounds. The whistles of porpoises, the cries and blares of whales have become familiar to scientists. These sounds are believed to be used for communication between animals, perhaps to send messages. In one instance, a school of porpoises swam close to some pilings and stopped while one member swam ahead. When the lone porpoise returned, all the porpoises whistled a great deal. Then the whole school swam through the pilings safely. It appeared that the lone porpoise was a scout that was sent ahead to bring back a report.

The scout porpoise could find the way ahead because of its sonar, which uses sounds that your ears can never hear. Dr. Winthrop Kellogg, of the Stanford Research Institute at Menlo Park, California, has found that a porpoise can tell a live fish from a dead fish by the echoes it sends back. And a porpoise can tell a six-inch fish from a 12-inch fish—20 feet away.

Journey Through the Deep

You would hear the whistles of porpoises if you went on an underwater listening trip. As you traveled along, you would also hear hundreds of shrimp snapping their "fingers"—special noise-making claws. You might hear the drumming sounds of fishes whose bodies have an air-filled organ called a *swim bladder (see diagram)*. This swim bladder is important in underwater sound-making, because it makes the sounds louder. Many fishes, such as the damselfish, have special muscles that vibrate the swim bladder to make drum-like noises.

As your trip continued, you could hear the rasping sounds of fish gnashing their teeth or rubbing their fins against their bodies. As a school of sperm whales swam by, you might hear their clicking sounds, which one scientist compared to "a hundred carpenters hammering nails into a roof."

If you could make this trip, you should remember that the sea-dwelling animals would not hear what you hear. Their ways of hearing sound, like their ways of making it, are very different from ours. After all, sound behaves differently in water. More energy is needed to produce sound underwater, but sound travels much faster in water—nearly five times faster than in air. Besides, there is another form of sound that underwater animals find important.

The sounds you hear are caused by changes in air pressure on your eardrums. Every sound produces waves of air pressure, and the inner part of your ear turns those waves into nerve signals that are sent to your brain. Underwater sound produces the same kind of pressure waves, this time in water. But because a lot of energy is needed to create these waves, the water can actually be pushed out of place, or *displaced*, by this energy. This *displacement* is the second form of sound heard by sea animals. Displacement is important only over short distances, but many fishes and other water animals can detect it.

Underwater "Ears"

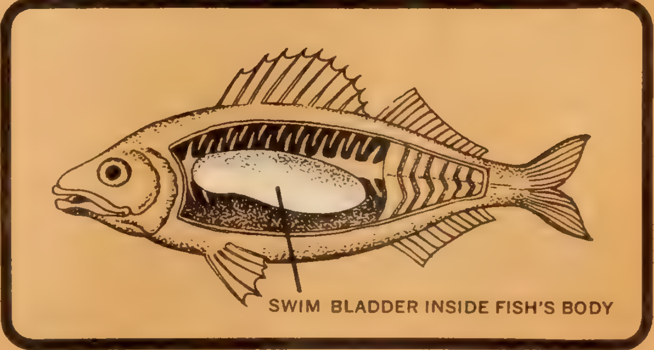
The ears of fishes are not nearly as good as ours. You might not think that fishes have ears at all—their heads have nothing sticking out to collect sound. But sound pressure waves travel right through a fish's body, so it can hear with an ear that is buried inside its head. If you looked at a fish's ear, you would find that it does resemble the inside part of a human ear.

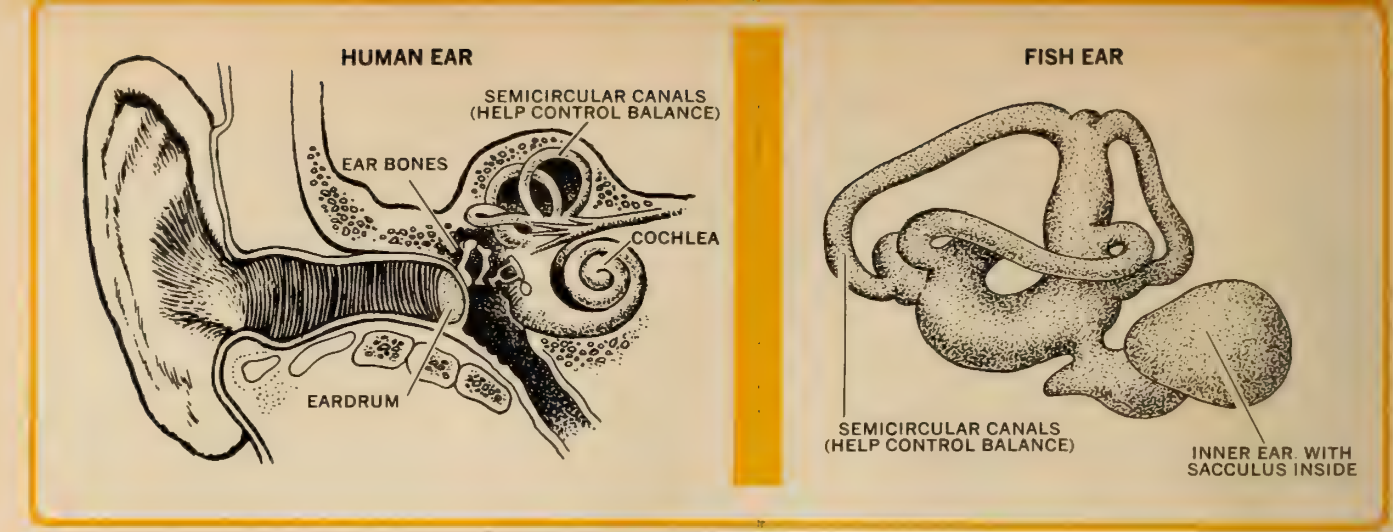
There is one major difference. Each of your ears has a spiral section, the *cochlea (see diagram, next page)* where sounds are turned into nerve signals. The cochlea can detect very slight differences in sound, which is why we hear so well. Fishes' ears do not have anything as delicate as a cochlea. Instead, they have an organ called the *sacculus*. As the name implies, this is a sack-shaped organ. It is filled with liquid, lined with hair and contains three floating bones. Sound waves move the bones, and the motion starts the hairs waving. That creates nerve signals for the brain.

The sacculus appears to be a much cruder instrument than the cochlea. But Dr. William N. Tavolga of The American Museum of Natural History has uncovered evidence which hints that the sacculus may be able to do more than it has been given credit for.

You can hear the difference between sounds of different frequency, or pitch, because each different sound affects a different section of a long, spiral membrane inside your cochlea. The boom of a bass drum starts one section of the membrane tingling, while the shrill sound of a fife is detected by a different section of the membrane. So if you hear a very loud sound at one frequency, you would not be able to hear a lower sound of the same frequency. The lower frequency sounds are "masked" by louder sounds in the same frequency. (You are still able to hear sounds at other frequencies.)

(Continued on the next page)




HUMAN EAR
SEMICIRCULAR CANALS (HELP CONTROL BALANCE)
EAR BONES
COCHLEA
EARDRUM
FISH EAR
SEMICIRCULAR CANALS (HELP CONTROL BALANCE)
INNER EAR. WITH SACCULUS INSIDE

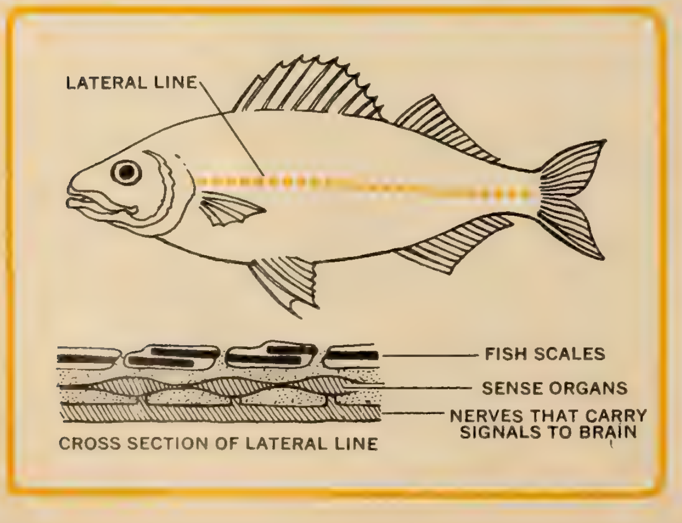
The Not-So-Silent World (continued)

The sacculus in the ear of fishes does not have a delicate membrane like the one in the human ear. But Dr. Tavolga has found that the "masking" effect exists in fishes. Does something in the sacculus of a fish's ear allow this to happen? If so, how? Dr. Tavolga is trying to find out.

The Better To Hear You With

The fishes that hear the best are mostly those that have swim bladders to help pick up sounds. The swim bladder starts vibrating when sound pressure waves beat on it, just as a drum vibrates. The bladder's vibrations are carried to the fish's ears by a set of small bones. So a fish with a well-developed swim bladder not only can make sounds better, it can also hear them better.

Fishes have another sound-detecting device—one that cannot be compared to anything that people have. This is the *lateral line*. It is made up of a large number of tiny sense organs that form a visible line along the side of a fish *(see diagram)*. The lateral line detects changes in the displacement of water caused by underwater sound waves and the movements of other fishes. It seems to help guide the precise movements of fish when they travel in schools. It allows each fish to detect the movements of the fish next to it. You may get a better idea of how the lateral line works if you have ever sat next to a booming bass drum and felt your feet tingle. This is roughly the same kind of feeling that the lateral line detects.


LATERAL LINE
FISH SCALES
SENSE ORGANS
NERVES THAT CARRY SIGNALS TO BRAIN
CROSS SECTION OF LATERAL LINE

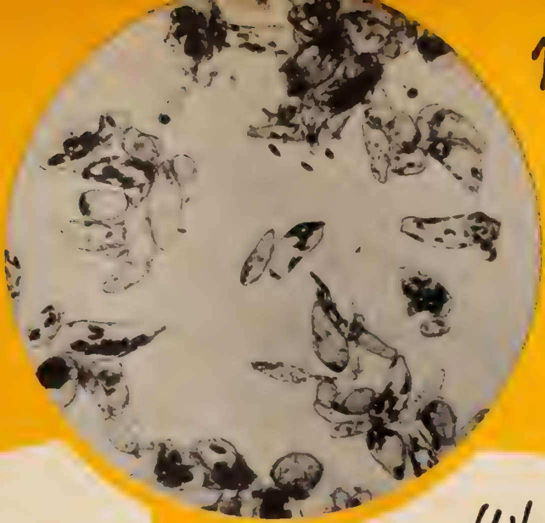
Man is just beginning to learn about underwater sound made by animals. There are still many unanswered questions. Scientists hope to learn more about the sounds of porpoises—probably the most intelligent of sea animals. Scientists are also working on plans to use them for herding fishes the way sheep are herded. The study of sea animal sounds will bring more surprises, since it is a young science. No one now calls the sea a "silent world" ■

In his studies of the sounds and hearing of fishes, Dr. William Tavolga of The American Museum of Natural History uses a tape recorder attached to an underwater microphone.

Brain Boosters

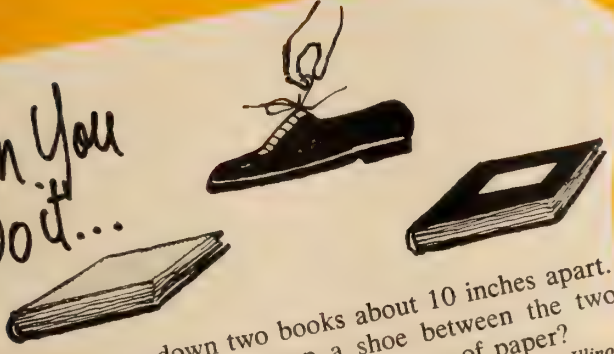
prepared by
DAVID WEBSTER

Mystery Photo



These banana cells were photographed through a microscope after being stained with iodine. Some of the cells came from an unripe banana, and others came from a ripe one. Which cells came from the ripe banana?

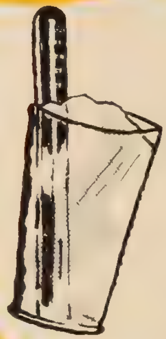
Can You Do it...



Lay down two books about 10 inches apart. Can you hold up a shoe between the two books by using just one piece of paper?

Submitted by Steven Recker, Lansing, Illinois

What would happen if...



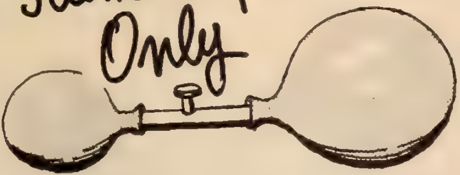
...a thermometer is frozen in ice? Put a glass of water with a wood-back thermometer in it into your freezer. How cold is the ice? Does the thermometer break?

Fun ith numbers and Shapes

How are these numbers arranged?

8549176320

For Science Experts Only



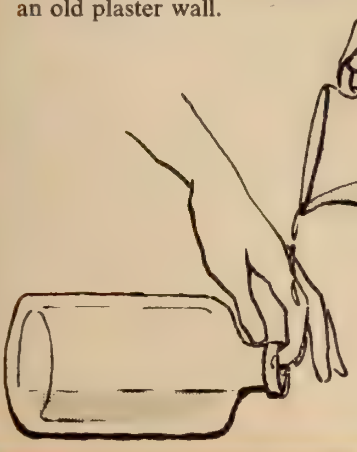
When the valve between the two balloons is opened, most of the air from the smaller balloon will go into the big balloon, making it even bigger. Why does this happen?

Just for Fun

What happens to some soil if you put it in your freezer?

ANSWERS TO BRAIN-BOOSTERS APPEARING IN THE LAST ISSUE

Mystery Photo: The photograph shows paint peeling off an old plaster wall.



Can you do it? You can use your finger to pour water slowly into a bottle on its side *(see diagram)*.

What will happen if...? When you turn a glass of water, the water spins quite a bit slower than the glass was turned, but continues to move for a long time. What would the water do if you first turned the glass one way and then the other?

Fun with numbers and shapes: The sum of the runs scored in each game by the Los Angeles Dodgers will be greater than the product of the runs scored in each game by the New York Yankees. The Yankee runs multiplied together will equal zero, since they will have scored no runs in at least one game. Zero multiplied by any other number is zero.

For science experts only: When a light bulb burns out, the *filament* breaks and prevents the electricity from flowing through the bulb. What causes the filament to break?

Hunting with Echoes

Can you tell a fat fly from a skinny one by bouncing sound waves off them? A bat probably can. Here is how biologists are studying the amazing echo-hunting ways of bats.

by Laurence Pringle

■ A bat was once let go in a room "full" of mosquitos. It caught 175 mosquitos in just 15 minutes—about one every six seconds!

To zero in on their prey, bats send out high-pitched sounds that we can't hear, then listen to the echoes that bounce back from the insect *(see above)*. But just how accurate is this way of hunting? Do bats make mistakes, catching raindrops and falling leaves as well as insects? Can bats tell one kind of insect from another, just from the echoes that return? These questions puzzled a group of biologists at Cambridge, Massachusetts, and in 1964 they set out to find the answers.

Bat Detectors and Mealworm Guns

First, a "flight room" was needed for the experiments. One was built that measured about 10 meters long, five meters wide, and five meters high (a meter is 39.37 inches). The biologists also set up a "bat detector"—a device that changes the high-pitched squeaks of bats into clicks that can be heard by humans. Cameras and high-speed flash equipment were readied to study bats' flight and their ways of catching objects *(see photos and diagram)*.

The last piece of apparatus was a "mealworm gun"—a sort of small cannon triggered by electricity that hurls small objects, including mealworms, into the air. (A mealworm is the larva of a certain kind of beetle.) The mealworm gun was put in the center of the floor near one end of the big room.

While the flight room and equipment were made ready, several dozen bats were caught in caves and other hideouts. They were all the same species, little brown bats. Then the tests began. The biologists would first release a hungry bat in the room and it would begin flying about. Then a mealworm would be fired into the air.

Some bats learned to catch the mealworms easily, others took longer, and some never learned to catch any. After a few weeks, the biologists picked just nine bats for further study. These nine were all healthy and had learned to catch 90 per cent or more of the mealworms that were tossed into the air.

Ugh . . . a Plastic Disk

By now these nine bats had learned where to expect a mealworm to "fly" by. Each bat flew up and down the room, usually in a figure-8 pattern. As it came near the mealworm gun, the bat would fly more slowly and would speed up its high-pitched squeaks, searching for a target.

Next came a surprise for the bats. The mealworm gun began firing *two* kinds of targets—sometimes a mealworm, sometimes a plastic disk. The disks came in six sizes, but all were close to the size of a mealworm (about a half inch to an inch long). The biologists watched carefully, wondering how the bats would react. This was a real test of the bats' echo-hunting system. Could they tell the difference between the mealworms and the disks?

The bats reacted in different ways. Some continued catching most of the mealworms but also caught most of the disks. In a few days though, they learned to avoid most of the disks. Other bats solved the problem by avoiding most of *both* mealworms and disks. Then they gradually began catching more and more mealworms, leaving the disks alone. In a few days it was clear that all nine bats could tell the mealworms from the disks. The most skillful bats caught 98 per cent of the mealworms and avoided 85 to 90 per cent of the disks.

Just how the bats told the disks from the mealworms is still not known. The biologists studied the kinds of echoes bounced off both kinds of objects. Once in a while they could detect a difference in the sounds, but it wasn't easy. Yet the bats could easily tell a disk from a mealworm—in perhaps a tenth or fifth of a second.

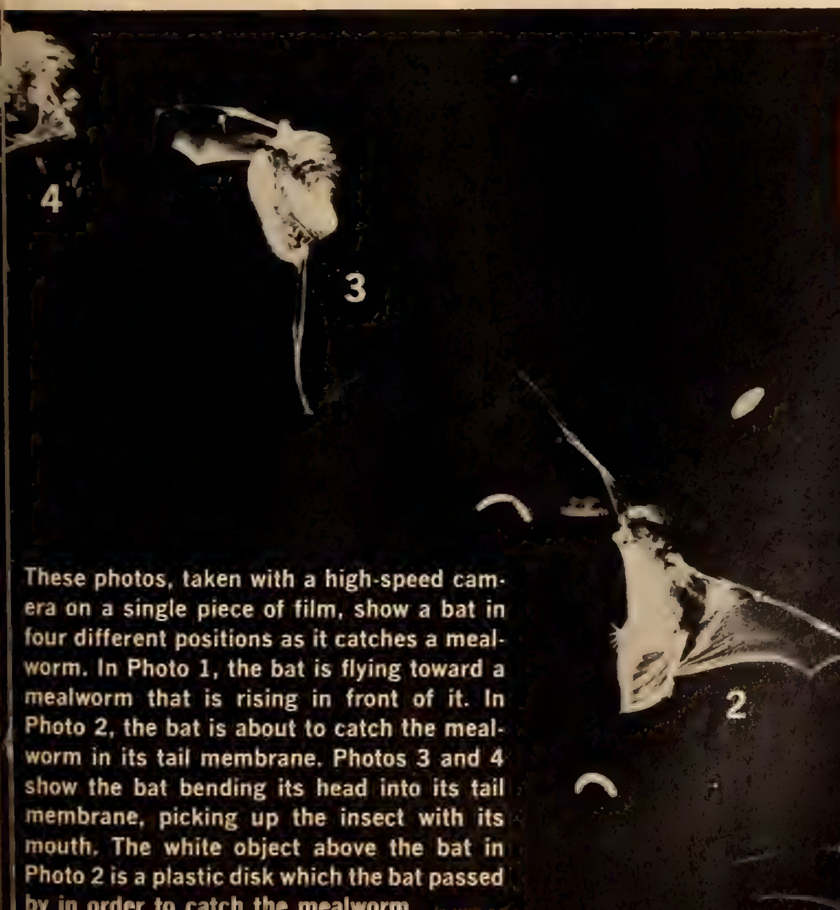
"Bagging" a Mealworm

While learning that the bats' echo-hunting can be very accurate, the scientists also discovered something about the animals' ways of hunting. High-speed photos showed that the bats usually caught prey in their tail membrane (which stretches between their tail and hind feet). Zooming in on a mealworm, a bat aims so that the insect hits the center of its tail membrane, which is snapped forward at that instant to form a sort of pouch. Then the membrane is bent up toward the bat's head and the head is turned down so the bat can grab the mealworm with its mouth *(see photo)*. All this happens in a fraction of a second.

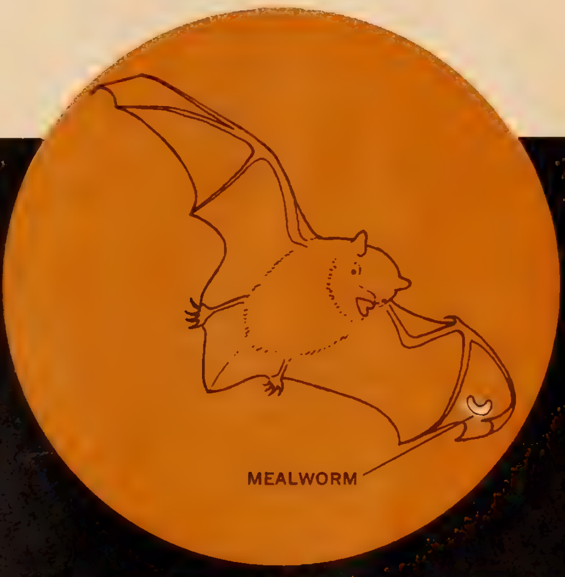
Bats also use their wings to catch prey, forming a scoop with their wingtip like a baseball player's glove *(see diagram)*. When an insect is snagged, the bat swings its wing inward, putting the prey in the pouch formed by the tail membrane. From there the insect follows the usual route to the bat's mouth.

Although these studies have revealed a lot about the ways of bats, they also raised some more questions. The biologists still wonder, for example, how accurate bats are when they hunt in the wild, not in a laboratory. After all, the nine little brown bats chosen for this study were all expert mealworm-catchers. Some of the other bats that were tested never learned to catch mealworms at all. We still don't know if bats occasionally catch raindrops or falling leaves.

These studies show that at least some bats can learn to tell very similar objects apart. Perhaps bats can even tell a tasty insect from one that they know is bad tasting. So far, no one knows. There are enough puzzling questions about the echo-hunting of bats to keep biologists busy for years to come ■



These photos, taken with a high-speed camera on a single piece of film, show a bat in four different positions as it catches a mealworm. In Photo 1, the bat is flying toward a mealworm that is rising in front of it. In Photo 2, the bat is about to catch the mealworm in its tail membrane. Photos 3 and 4 show the bat bending its head into its tail membrane, picking up the insect with its mouth. The white object above the bat in Photo 2 is a plastic disk which the bat passed by in order to catch the mealworm.



Bats sometimes catch insects in a scoop formed at the end of their wingtips. The insect is then put into the tail membrane, where the bat grabs it with its mouth.

HOW IT WORKS

Tape Recorder

■ A tape recorder turns the sound of your voice into a magnetic code on a strip of tape that you can store and play back whenever you wish. Each time, your voice and words will sound exactly the same. Here is how it works.

When you switch on the recorder, the tape begins to unwind from one reel and onto the other (*see Diagram 1*). This tape is a ribbon of plastic, usually ¼-inch wide, that has tiny particles of iron spread in a film on one side. (On a fresh tape, the particles point all different ways.)

Between the reels, the tape passes over the *recording head,* which is connected by wires to the *microphone.* As you speak into the microphone, your voice makes sound waves in the air that push a thin metal plate, or *diaphragm,* back and forth in the microphone. When the diaphragm is pushed inward, more electric current flows through the microphone than when the diaphragm moves outward. A loud sound makes more current flow than a faint sound, because the waves made by a loud sound push the diaphragm farther than the waves made by a faint sound. A high-pitched sound moves the diaphragm in and out faster than a low-pitched sound, so a high sound changes the flow of current more times per second than a low sound.

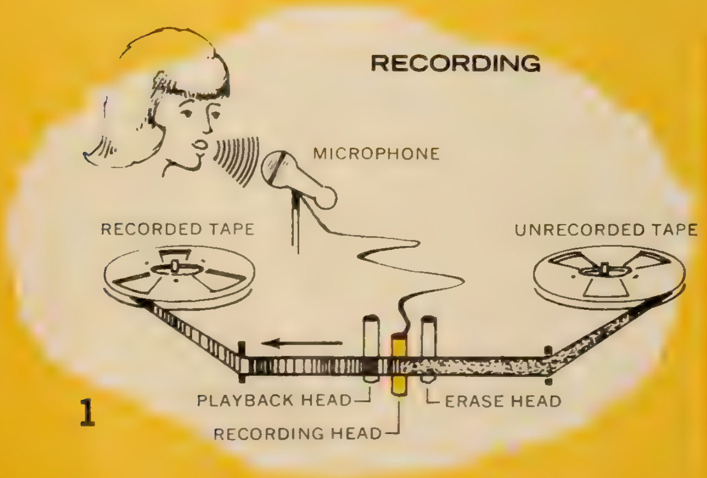
The current made by the sound waves flows from the microphone through a wire coil in the recording head, making the coil an *electromagnet.* As the tape moves across it, the electromagnet pulls on the iron particles and makes some of them line up in the same direction, so that they form magnetic spots on the tape. (The same thing happens to the particles of iron in a nail when you stroke it with a magnet.) A strong pull from the electromagnet (loud sound) makes strong magnets on the tape. A weak pull (faint sound) makes weak tape magnets. A rapidly changing pull (from high-pitched sound) gives the particles that are close together different magnetic strengths. A slowly changing pull (from low-pitched sound) makes the strengths of the little magnets change more gradually along the tape (*see Diagram 1*).

To turn this magnetic record of your voice back into sounds, you press a button that disconnects the recording head and connects the *playback head* (*see Diagram 2*). The playback head also contains a wire coil. When a magnet is moved around near a wire coil, it makes an electric current flow in the wire. This is what happens as the magnetic spots on the tape move past the coil in the playback head. And the harder a magnetic spot on the tape pulls, the more current flows in the coil.

This constantly changing current is then *amplified,* or strengthened, and fed into the *loudspeaker.* There the current goes through the coil of another electromagnet, which pulls a piece of iron back and forth each time the current changes its flow. The iron is attached to the center of a stiff paper cone, called the *diaphragm.* The diaphragm pushes the air in and out, making sound waves just like those you sent into the microphone.

To erase sound from a tape, you turn on the erasing head. The current in its wire coil keeps changing so fast that the iron particles on the tape are scrambled up again.

Even television signals can now be recorded on magnetic tape and played back through a TV set to reproduce the original picture as well as the sound ■



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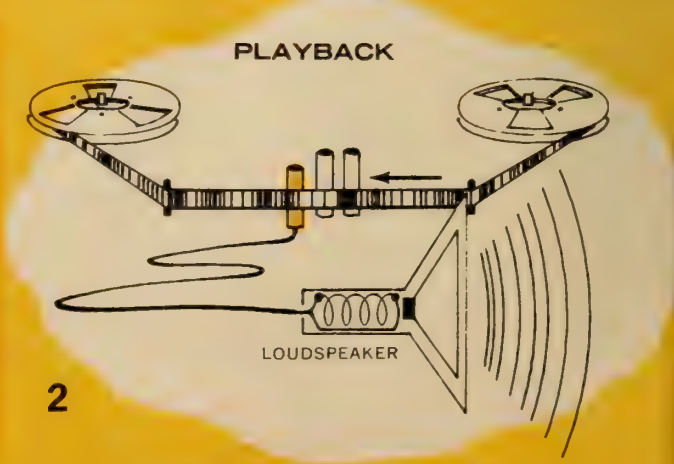


2

Suggestions for Using . . .

(continued from page 2T)

the straw and just touching it. Make the blade vibrate through a distance of about half an inch and move the slide under the straw at an even speed. The wavy line on the slide is a picture of the blade's vibrations—and of the waves it makes in the air.

See if your pupils can interpret the picture. The distance from the top of one peak to the bottom of the next valley shows how far the blade moved in one vibration—and it also shows the strength of the wave it made. If you could move the slide for just one second, the number of peaks made in that time would be the frequency of the vibration wave (so many cycles per second), and the distance from the tip of one peak to the tip of the next one would be one wave length.

References

Many excellent ways to test and observe the characteristics of sound waves are supplied in these books:

- *Teaching Elementary Science,* by Elizabeth B. Hone, Alexander Joseph, Edward Victor, and Paul F. Brandwein, Harcourt, Brace & World, Inc., New York, 1962, $7.75.
- *700 Experiments for Everyone,* compiled by Unesco, Doubleday & Company, Inc., Garden City, N.Y., 1958, $3.
- *Sound,* by Verne N. Rockcastle, Cornell Science Leaflet Vol. 54, No. 1, available from Cornell Science Leaflets, Cornell University, Ithaca, N.Y. 25 cents.

One way to make a glass vibrate without tapping it *(see "Making and changing Sound Waves")* is to wet the tip of your finger and rub it firmly along the top edge of the glass. Another way is to tap another glass of identical size, shape, and material close to the first glass. The sympathetic vibrations in the untapped glass are usually hard to detect, though.

Hunting with Echoes

This article and "The Not-So-Silent World" illustrate the concept: *all organisms are adapted to their environment.* The amazing echolocation ability of bats is an especially good example of this concept.

This article emphasizes the ways in which bats hunt by echoes; you might remind your pupils that bats also navigate by echoes, avoiding obstacles as they fly. Bats are not blind but their eyesight is weak when compared with most mammals. One of the many unsolved mysteries about bats concerns the ability of some migratory species to find their way to and from wintering areas that are several hundred miles from their summer homes.

Topics for Class Discussion

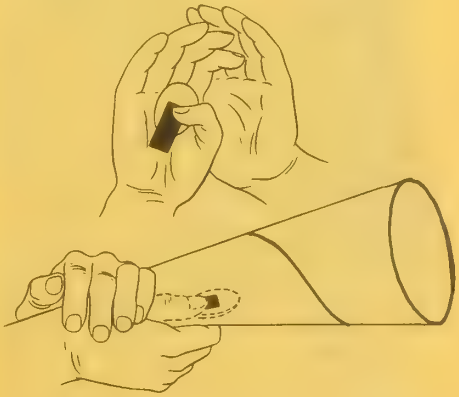
This article reveals some ideas about how scientists go about setting up an experiment. In order to keep the article simple, however, some important details about experimental design had to be eliminated. You might use the following discussion questions to help give your pupils some insight into the problems of setting up an experiment.

- *Why did the biologists use bats that were all of the same species?* Different species of bats catch their food in different ways. Big bats usually catch bigger insects than small bats. Some bats, such as fruit bats, don't eat insects at all. In an experiment, it is important to reduce the number of variables so that you are testing just one thing.
- *Why did the biologists use only bats that were expert at catching mealworms?* The purpose of the experiment was *not* to find out if little brown bats could catch mealworms, but to find out if the bats could tell mealworms from plastic disks. It was important, therefore, to pick bats that were expert at catching mealworms. If "poor catchers" were used, another variable would have been introduced into the experiment.
- *The tests were only done when the bats were hungry. Can you guess why?* By making sure the bats were hungry, the scientists eliminated another variable in the experiment. If well-fed bats were used, there could be two possible explanations for a bat missing a mealworm: 1) the bat *failed* to catch it, or 2) the bat *didn't try* to catch it. Using only hungry bats, the scientists could assume that the bats were "trying their best" to get food. The scientists could tell if the bats were hungry or not by observing their behavior; when hungry, the bats flew repeatedly over the mealworm gun.
- *Do you think it would matter in what order the mealworms and disks were fired into the air?* If objects were presented to the bats in a regular order, the bats might learn when to expect a disk or mealworm, thus affecting the results of the experiment. The objects were fired into the air in a random sequence.
- *What other problems might scientists encounter in an experiment like this?* The scientists had to be sure that the disks and mealworms followed similar flight paths when fired from the mealworm gun; most of the experiments were done in the light but some were done in darkness to see if light had an effect on the bats' accuracy (it did not); and to find out if bats might tell mealworms from disks by smell, the scientists smeared body juices from mealworms on some disks (again, no effect).

Activity

Your pupils can investigate echolocation by using a small toy frog or cricket—the kind with a thin strip of spring steel that makes a loud, short clicking sound when you bend the end of the strip with your finger. You may be able to buy one for about 10 cents at a variety store.

The clicker should be held so that some of the original sound is blocked from reaching your ears and to make it easier to hear the echo. The diagrams show how to hold your hands to form a cup facing away from you, or how to use a cone of thin cardboard to get the same effect.



With this clicker, your class might try to find answers to questions like these: Can you use echoes to tell how far you are from the side of a building or wall? Do echoes from trees sound the same as echoes from buildings? Can you detect an object as small as a chair by its echoes? Blindfolded, can you accurately find your way along a hallway by using the clicker and listening to echoes?

Thoughts on Sound and Hearing

(continued from page 1T)

easily listen to a joke being told by someone on your right and the next moment "switch" to a couple of giggly girls behind you, without even moving your head. Your ears were getting the same sounds all the time, but you directed your attention now here, now there.

If you had made a tape recording of the party with a single microphone at the spot where your head was, you would not be able to make any sense of the playback; you could not "direct" your attention anywhere but to the loudspeaker. The same sounds that were such fun to you at the party are now a garbled racket. Obviously *listening,* that is, concentrating on a particular sound, is not as "simple" as it seems.

Listening for Food

It is a striking thought that a creature hears its food, because in our own, human, perception we tend to associate smell and sight with the idea of sensing food; sounds play at best a very minor role. Yet many animals rely heavily on their hearing for a square meal, and some have no other means at all to obtain food.

Owls apparently hear the rustling of a mouse in the grass before they swoop down close enough to see the prey. But the most wonderful example of "hunting by ear" is provided by the bats. *(See "Hunting with Echoes" and page 7T.)*

Sounds for Communicating

The sense of hearing is really a "long-distance" sense; it becomes most important when the other senses—vision, smell, touch—cannot operate any longer because of obstructions or sheer remoteness from the thing to be sensed.

When a forest is densely populated with, say, a particular species of finch, it is quite probable that males and females meet each other by accidentally wandering within viewing distance. They never would have to utter a sound to make their positions known. On the other hand, finches establish *territory;* that is, each male "stakes out" a plot of forest, usually indicated by some natural markers such as odd trees, clearings, and so forth, but sometimes quite vague. This plot he considers his property, and he is determined to keep all intruders, especially other male finches, out of it. To make it known to all comers that they trespass at their own risk, he perches at the highest point in his domain and sings his characteristic "territory song."

If our finch lived in a sparsely populated region he would have little need for insistence on his rights, since no other male would bother him. But by the same token he would have trouble meeting a female, unless he perched in a treetop again and sang a "come hither" song to make it known that a bachelor of means, solid citizen, with large home, offers security to unattached female—apply in person.

These examples illustrate the role of hearing in *communication.* One bird makes a sound which informs the other of the state of mind of the caller: He is determined to keep other male finches out, but is anxious to have girl finches come in. There is a real *message* in these calls—that is, a "personal" note. It does not just inform any listener of a bird's being there; it specifically tells all other finches that here sits one finch who has no use for other finches except females.

You can think of many other examples, such as the clucking of the hen, which tells the chicks, "Mother has found food"; or the screeching of the blue jay, which informs other blue jays—and, incidentally, all sorts of other animals that have learned to heed the jay's noise—that he has seen danger approaching. It is this *sending and receiving of meaningful messages* which I will refer to as *communication.*

Fear, Joy, and Thought

In most animals communication by sounds is extensively used for the expression of emotions: Anger, fear, joy, satisfaction, the sex urge, and sociability have characteristic sounds associated with them. A dog snarls and growls when angry, yelps and whines when scared, barks or yips when happy. Cats purr when satisfied and make the most hideous racket during courtship.

In man we find some of the same characteristic sounds. We scream, groan, chuckle, sob, yell, and howl; you can easily identify the emotions expressed by these sounds. However, in the human being this basic system of communication is superseded by our ability to use sounds as building blocks in a *symbolic code* of communication which we call *language.*

Not only can we express our basic emotions in this coded form, but we use it to express rational thoughts, even very abstract ideas. Some people argue that we can think rationally only because we have a language. This argument has a lot to recommend it; just try for yourself to think about something without "thinking in words," or perhaps in numbers, which are after all also a code. Of course, you must not think of emotional subjects such as a friend of the opposite sex—that I call "dreaming." But you will probably find it impossible to think about any prosaic subject, such as how you will spend the rest of the day or the rest of your money, without using words. For most people, as far as I am aware, thinking involves "talking to themselves" ■

nature and science
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They Mean What They Say —But They Don't Say What They Mean

by Brenda Lansdown

■ Most teachers have worried at one time or another about how to explain science to children. That worry may be on the way out. A new trend in science teaching is to let children have experiences with materials, then to let the children offer explanations of what they have discovered.

This, in turn, gives birth to another worry: "Suppose the children's explanations are wrong!" We all worried little when our own explanations to children were wrong. Perhaps that was because we didn't know it at the time, or we wouldn't have offered them. Let me lay this ghost at once. Children's explanations aren't wrong, for what they know and for the way they are thinking. Inadequate, yes. But how adequate are any explanations? Try explaining to yourself how an electron buzzes around an atomic nucleus, and I think you will see what I mean.

"But what do I do when a child gives a wrong–excuse me, I mean an inadequate–explanation?"

Congratulations, you DO something; you don't counter with another explanation. What you do depends very much on what the child has in mind. That's it! In *his* mind. How do we find this out? We ask him.

"Tell Me More"

Jeremy announced after a 45-minute exploration with materials that sank or floated or could be made to do either, that things sink because they are light, and float because they are heavy. "Tell me more about it," urged the astonished teacher.

"Well, an ocean liner is heavy, very heavy, and it floats, but my ping-pong ball with the hole in it is light, even when it filled with water, and it sank," replied this thoughtful eight-year-old.

He *did* mean what he said, but he didn't say all that he meant. It was the teacher who failed to understand the meaning of the first announcement. So what did she *do?* At the next session she gave Jeremy pairs of objects to throw in his water tank, each pair having roughly the same shape and volume but different densities: a small rock and a plastic sponge cut to the same shape; a needle and a toothpick; a lightly squashed-up piece of aluminum foil and a marble; a cork and a rubber stopper.

What was Jeremy's explanation after putting these materials in water? He didn't say he was wrong last time. He wasn't. He decided that "When two things are the same size, the heavier one sinks." The old explanation had been superceded by a more adequate one. Is this the full explanation of flotation? Certainly not! But, educationally speaking, how far has this young scientist come along the road scientists travel? Quite a way in roughly 90 minutes.

If you'd like to go further with Jeremy, you'd have to challenge him with more materials. But materials are more easily thought up than produced. (Fortunately some of the new science programs being developed over the nation are now producing materials structured for discovery.)

Suppose you could give Jeremy

(Continued on page 3T)

Brenda Lansdown is an Associate Professor of Education at Brooklyn College of The City University of New York.

nature and science
A PEEK INTO THE OCEAN WORLD

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

How the Dentist Fixes a Cavity
Your pupils can find out—painlessly—how a cavity grows and what a dentist can do to stop it.

● **Make Your Own Sea Aquarium**
This SCIENCE WORKSHOP gives directions for setting up and caring for an inexpensive salt-water aquarium, plus hints on how to study the captive ocean animals.

● **Swallowed by a Snake**
Pictures show how a snake's ability to swallow large objects helps make it an efficient food-getter even though it has no arms or legs.

Brain-Boosters Contest
Your pupils—or you—may win a microscope or telescope.

Has "Lost Atlantis" Been Found?
This ancient nation was said to have sunk into the Atlantic Ocean several thousand years ago. But scientists believe they have found its site—in the Aegean Sea.

● **Measuring Raindrops**
Your pupils can use simple equipment to find out how raindrops differ in size at various times in a storm.

IN THE NEXT ISSUE

SCIENCE WORKSHOPS on probability and fingerprint study and detection ...How people began to grow their own food...A WALL CHART on adaptation through natural selection ...The origin of your Thanksgiving turkey...Making bird feeders.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Sea Aquarium

Until the past few years, only people living near oceans could keep salt water aquariums with any degree of success. Now a number of companies sell certain salt water animals through the mail and several brands of aquarium salts are available.

If you have never tried keeping an aquarium before, you might first get some experience with a freshwater tank. Many of the directions for setting up a salt water aquarium also apply to a freshwater tank. However, you won't have to worry about such problems as salt corrosion of metal parts and the salt concentration of the water.

Your pupils should help plan for, set up, and maintain the aquarium. Possibly one of your pupils already has a neglected but still useable tank that can be borrowed for use by the class. If an aquarium tank has been dry for a long time it should be treated with sealer before water is added. Once the aquarium is set up, individual pupils or teams can be assigned such tasks as changing filters, checking salinity, and cleaning the tank.

With any kind of aquarium, the two main sources of trouble are overcrowding and overfeeding. In the schoolroom, maintenance can be a problem on weekends and holidays. Before such times the tank's top should be tightly covered (to prevent excessive evaporation). Avoid excessive feeding before a weekend or holiday; it is better to add no food than to risk overfeeding that might result in a polluted tank.

Besides the sources mentioned in the article, the Supply Department of the Marine Biological Laboratory at Woods Hole, Massachusetts, sells salt water animals (but only to schools, colleges, and investigators who supply them with an official purchase order number).

References

Whether you plan to set up a salt water aquarium, an aquarium for tropical or pond animals, or just a wide-mouthed jar containing a salamander or snail, these references (and the ones listed with the article) will be helpful:

- The article, "A Pond in Your Living Room" (N&S, *Oct. 4, 1963*) is also available in N&S Resource Study Unit No. 105, *Investigations with Animals.*
- The classic reference on aquarium keeping is *Exotic Aquarium Fishes,* by William T. Innes, Aquarium Publishing Co., Norristown, Pa., 1956, $9.75.
- Another useful adult book is: *Aquariums,* by Anthony Evans, Dover Publications, Inc., New York, 1952, 65 cents.

Swallowed by a Snake

In showing how a snake swallows an egg, this picture story emphasizes the concept that organisms are adapted to their environment. The most obvious adaptations are structural ones—snakes' jaws, the feet or beaks of different kinds of birds. But adaptations may also be behavioral (a species of bird building its distinctive nest) and physiological (the venom of a snake, an enzyme in an animal that digests plant cellulose).

Make sure that your pupils do not confuse *adaptability* with *adaptations.* A chameleon shows adaptability when it changes color with its surroundings. Humans show adaptability when, after living in the thin air of high altitude environments for a time, their bodies produce more oxygen-carrying red blood cells. *Adaptability* is a capacity to adjust to changed conditions in the environment and is itself a kind of adaptation.

When discussing adaptations, avoid the implication that an individual animal suddenly develops a feature that enables it to survive in its surroundings. *Adaptations* come about through natural selection over many generations, as explained in the article "How Did Spiders Become Spinners?" (N&S *and* Teacher's Edition, *Oct. 3, 1966*).

Activity

Have your pupils investigate and report on other ways in which animals and plants are adapted to their environment. There are examples elsewhere in this issue (salt water animals) and in recent past issues (bats, rats, spiders, wolves, dinosaurs, deciduous trees).

HELP A PHOTOGRAPHER

The School Science Curriculum Project is very much interested in determining how children interpret their observations. We would like to receive class-size sets of responses to the questions posed on page 13 (17 in Advanced Edition). Please do not tell the pupils of the affiliation of our Project with the article. Play the game along with them. It may prove to be quite enjoyable.

School Science Curriculum Project
University of Illinois
Urbana, Illinois

(The results of this study will be reported in a future Teacher's Edition.)

Raindrops

We regret to say that "Measuring Raindrops" was the only part of Dr. Blanchard's forthcoming book, *From Raindrops to Volcanoes,* which could be adapted for the readers of our regular edition. A series of articles adapted from the book begins in this issue of the Advanced Edition.

To those of you who receive the Advanced Edition, we would like to point out that this series provides an unusual account by a scientist of how he and others have studied a common but complex phenomenon—the birth of a raindrop. Many aspects of the physical

(Continued on page 3T)

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and science

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HAS "LOST ATLANTIS" BEEN FOUND?
see page 11

A PEEK INTO THE OCEAN WORLD

nature and science

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HOW IT WORKS

■ "Now rinse. That wasn't too bad, was it? See you aga
in six months."

With these friendly words your dentist is telling y
that all is well for the time being; but that, like everyo
else, you can expect to come back for another visit a
perhaps a new cavity before too long.

What, actually, did the dentist do when he filled th
last cavity? Let's find out by looking at one type of cavit
like the one shown in Diagram 1. In this tooth there a

How the Denti

some deep grooves on the chewing surface of the *enam*
the outer coating of the tooth. These grooves form wh
the enamel grows together as the tooth develops in t
jawbone. Because the grooves are much smaller than t
bristles of your toothbrush, food can collect in them a
cause the enamel to decay. Notice how deeply the groo
goes toward the border between the *dentin* and enam
There may not even be an opening at the bottom of t
groove. Usually there is, but it may be microscopic in si

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after printing: 145,000; (G) Total (Sum of E & F—should equa
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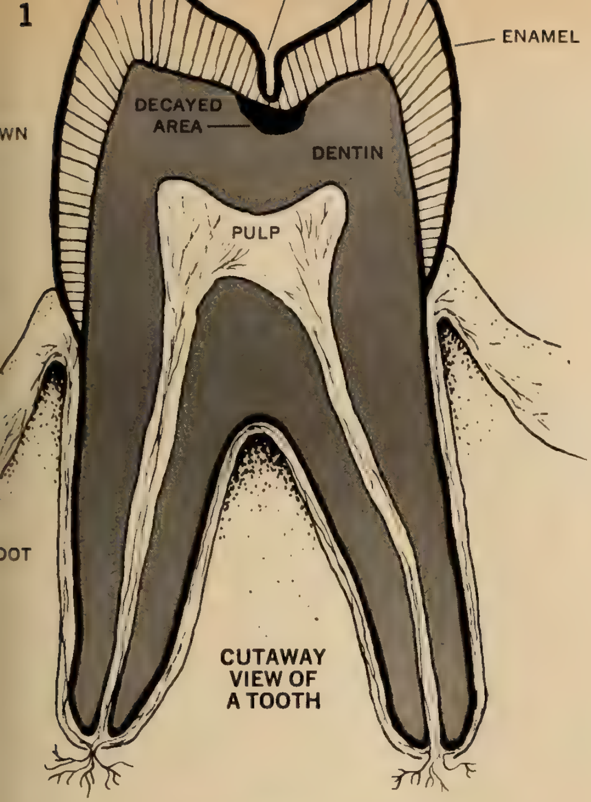
1



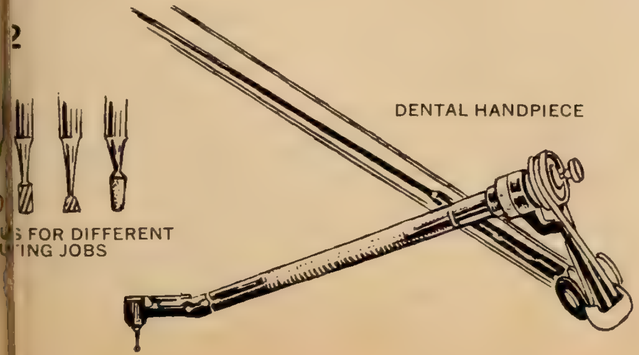
CUTAWAY VIEW OF A TOOTH

ixes a Cavity

l, it is big enough to allow bacteria to reach the dentin.
Also notice that the cavity begins to spread out in the
tin. The decay spreads more quickly in that area than
oes in the enamel because the dentin is softer than the
mel. It is softer because it has less *calcium,* the tooth
l bone-building element needed by the body. The cavity
ur diagram is a small cavity, which has not yet spread
y far towards the even softer *pulp,* which contains
ves and blood vessels. The decayed material inside the
ity is what's left of the hard dentin of the tooth, but
now soft, brown, and leathery. This is what the dentist
to remove from the tooth. How does he do it?

Now open." The *dental handpiece,* as the dentist calls
drill, holds cutting tips called *burs (see Diagram 2).*
h bur is shaped to do a different kind of cutting job. The burs are usually made of a very tough metal, *tungsten carbide.* Others are shaped like a wheel and are covered with small chips of diamond.

2



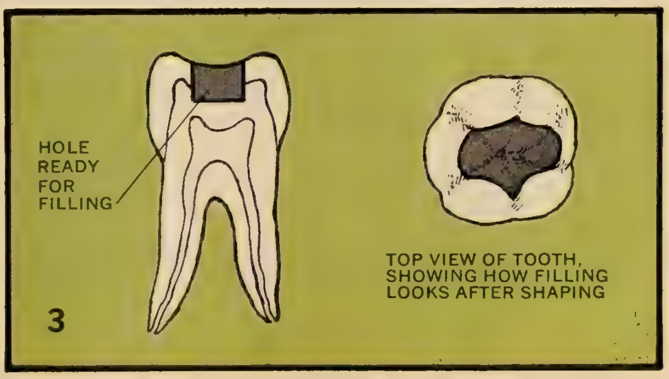
S FOR DIFFERENT
ING JOBS

"Open wider, please." Because the bur turns at very high speeds (up to 250,000 revolutions per minute), it heats the tooth, and gets hot itself. Because the heat can cause pain, a jet of air and water is sprayed onto the bur and your tooth to keep both cool.

Shaping the Hole To Be Filled

"Now rinse, and let's have a little rest." Drilling out the decayed material is only part of the dentist's job. He must carefully shape the hole so that the filling will stay in. What he does is drill a hole shaped like the one shown in Diagram 3. The finished cavity has fairly straight parallel walls and a flat floor. But that may surprise you. What keeps the filling from falling out when you bump your head hard, since the filling is not made of a sticky substance? It is held in place by the tight fit of the filling against the walls of the cavity. The filling presses so hard against the walls that *friction* between it and the walls keeps it from moving.

The cavity we are talking about in this article is going to have a filling made of fine particles of silver, with a little zinc, copper, and tin. This substance is mixed with mercury. The mercury partly dissolves the other metals and turns them into a soft mushy material called *silver amalgam.*



"Open again, please." After the dentist has mixed the filling material, he packs it firmly into the hole in your tooth with an instrument called a *plugger.* But first he may put in a cement liner to protect the dental pulp.

After the filling has been built up, the dentist shapes it with an instrument called a *carver.* He gives the top of the filling the same shape that the healthy tooth once had. The soft filling begins to harden within a few minutes, but it takes about a day for it to get as hard as it will ever get.

"Remember, six months. And don't bite on anything hard until tomorrow. See you later."

—Jerome D. Brent, D.D.S.

Make your own SEA AQUARIUM

by Barbara Neill

Even if you live far from the coast, you can set up your own miniature ocean and study the fascinating lives of animals from the sea.

■ How would you like to see a live barnacle catching food with its feet? Or a sea urchin gliding on its "tube-feet?"

The best place to see these things is in a salt water aquarium. Not a big public aquarium, but a 10 or 15-gallon aquarium that you can keep right in your own home or school. It can cost you as little as $15 to set up such a miniature ocean (even less if you already have a tank).

The most satisfactory salt water aquariums are all plastic or all glass. Salt water not only rusts the stainless steel of ordinary metal-braced tanks, but may " eat away" the aquarium cement. However, metal-braced tanks have been successfully converted to salt water tanks. You can buy an epoxy sealer (such as Silastic) from aquarium supply shops that covers and protects exposed seams and metal parts.

If you live near the ocean you can probably get some natural sea water. Farther inland, you can buy aquarium salts from an aquarium supply store to make artificial sea water. These aquarium salts will have complete directions on the package. Because ocean water is such a complex substance, it is not practical to try to make up your own combination of chemicals (although this could be an interesting experiment).

Getting Your Ocean Animals

Collecting your own specimens can be fun, and is less expensive than buying them. If you don't live near an ocean, however, write to some of the companies listed on the following page for their lists of available salt water animals. A growing number of companies send ocean animals to people who keep salt water aquariums far from an ocean. Whether you collect your own specimens or buy them, you should first have your aquarium tank ready for the animals.

If you can do your own collecting, a rocky beach at low tide is best. You will need clean plastic pails or enamel pails, a net, and a small plastic container. Remember that sea water will react or combine with other substances, especially metals. Just a trace of some metals can make the water poisonous to many small sea animals, so never use metal containers such as galvanized pails or tin cans.

The most difficult part of collecting is getting the specimens from the ocean to the tank, so take only very small animals and lots of water. It is easy to overcrowd the pail. You will probably see so many interesting things that it will be hard to keep from taking too many.

Here is an example of a collection in a 10-quart pail that could be expected to come through a trip of four or five hours in excellent shape: three one-inch hermit crabs, several small prawns, a three-inch starfish, six or seven mud snails, and a very small green crab. (The photos on the next page and the books listed at the end of the article will help you identify your catch.) Of course you may find entirely different animals when you go collecting—you might discover a little rock entirely covered with barnacles, or you might find feather worms, sea anemones, or a young horseshoe crab.

Very small fish of many species do well in aquariums. Toadfish, killiefish, stickleback, and opaleye (on the west coast) are especially hardy. Many of these fishes are aggressive and may eat smaller specimens. Some of the crabs give the same problem. When you are collecting, do not put a big fish or crab in the same pail with small ones. A big handful of clean seaweed added to the pail gives the small animals some hiding places. Then they will be less likely to try to jump out. To keep the water from sloshing about on the way home, you can stuff some crumpled newspaper into the top of the pail. Another good method of carrying water is to use large extra-heavy plastic bags put inside sturdy cardboard cartons. Be sure the water does not get too warm. A sudden rise in temperature will kill many animals.

Keep Them Alive

Once you have your animals at home, put them into the aquarium right away. Put the animals in gradually, mixing the water in the animal's container with the water in the aquarium, so there is no sudden change in temperature.

Now comes the challenge. Can you keep this collection in a healthy, natural state? Will the aquarium look as attractive a month from now? Will the water stay clear?

If you have kept aquariums before, you already know many of the common pitfalls. A salt water aquarium requires much the same care as an ordinary aquarium—plus a few extra precautions.

The first problem is the tank's location. This is important for any aquarium. Too much sunlight will speed the growth of green algae in both fresh and salt water. It is better to depend on an overhead reflector light and keep the aquarium away from direct sunlight. In the northern part of the United States, keeping the water cool may be a problem in the summer. During the hottest days ice cubes may have to be added occasionally. On the other hand, if you have fish or other animals from tropical waters, summer weather is just right. In this case, when the temperature drops much below 75°F you will need a heater and thermostat (available from aquarium supply stores).

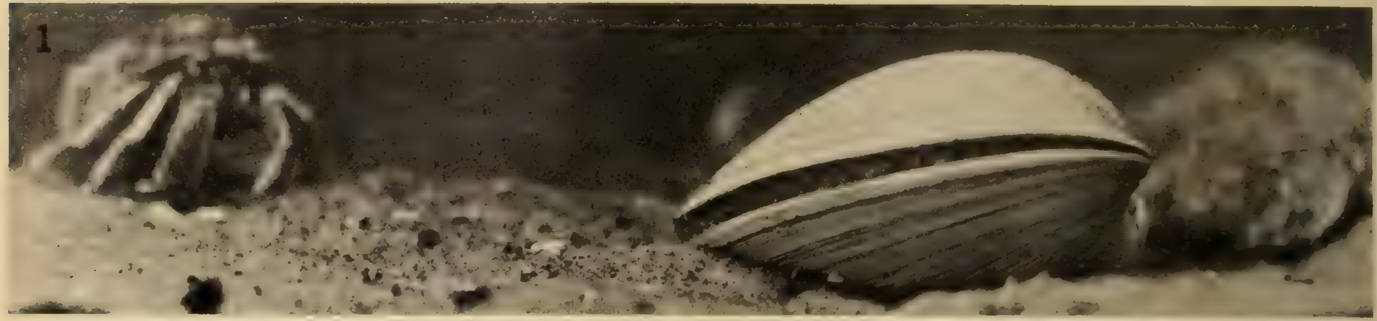
Most plants from the ocean (with the exception of certain small green algae, such as *Ulva*) are difficult to keep healthy. It is best to do without them, at least until you have had more experience in keeping a salt water aquarium. This does not mean that you will have a bare tank. Rocks, coral, and sand can be arranged to make your aquarium look like a bit of ocean floor. But don't use ordinary sand or rocks of mixed minerals; they may contain substances that will poison your animals. If you get seashore sand be sure it is perfectly clean. Rinse it several times in fresh water to remove all impurities.

Any pure quartz rocks are safe, and you can buy pure quartz sand especially for aquariums from aquarium supply shops or dealers. Coral must be thoroughly "cured" before it is safe. Soak the coral a day or two in fresh water, then see whether it has an odor. If it has even the slightest odor it may poison your ocean animals and must be soaked again until the odor disappears.

(Continued on the next page)

Even if you do not live near an ocean or near an aquarium supply shop, you can order equipment and some kinds of live specimens through the mail. Before ordering, be sure to write to the dealer to find out what animals are available. He may not carry the item you want; he may sell it only in large quantities; or he may have it only during certain seasons. Here is a list of companies that sell animals and equipment for salt water aquariums:

Aquarium Stock Company, 31 Warren Street, New York, N.Y. also at 8070 Beverly Blvd., Los Angeles, California
Gulf Specimen Company, P.O. Box 206, Panacea, Florida
Coral Reef Exhibits, P.O. Box 59-2214, Miami, Florida
P. G. Lynch and Associates, 2 Charles Street, New York, N.Y.
Ward's Natural Science Establishment, P.O. Box 1712, Rochester, New York
Ward's of California, P.O. Box 1749, Monterey, California



Here are a few kinds of ocean animals that you might keep in your aquarium. Photo 1 shows a fiddler crab (left) and a hard-shell clam, or quahog (right). In Photo 2, another hermit crab is shown in its "home"—an empty moon shell. Young hermit crabs live in small shells, such as those of periwinkles. The crabs move to bigger shells as they grow. The sea urchin in Photo 3 is eating algae from the rock on which it clings with its "tube feet." Sea urchins are related to starfish and sand dollars.

Make Your Own Sea Aquarium (continued)

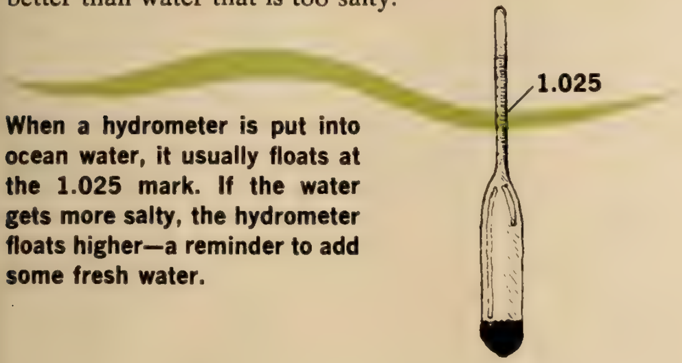
How To Keep an Ocean

If you have only a few small specimens (for example, two periwinkles, a one-inch hermit crab, and a two-inch baby flounder), it is possible to keep them in a five-gallon aquarium without any filter. However it is safer to use a filter, and if you get more animals, it will be necessary. Since a small tank needs nearly as much attention as a big one, use a 10 or 15-gallon tank if you can. It is easier to keep the temperature constant in a big tank.

You will need to buy a pump and filter from a pet store or aquarium dealer. They cost about $6. (A larger tank with many occupants may require several filters and a stronger pump.)

Your tank should be covered with a sheet of glass to keep water from escaping into the air (*evaporating*). Add fresh water from time to time to make up for the water that does evaporate. When you first fill the tank it is a good idea to mark the water line. Then always be sure that the water is at that level. When you add water, use distilled water, or tap water that has stood for a day or so to let the chlorine evaporate.

To check the amount of salt in the water, use a glass float called a *hydrometer* (*see diagram*). Notice the markings on the side of the hydrometer. When you first put the hydrometer into the salt water, it will probably float at the 1.025 mark. Later, if the hydrometer rises above this line, add the distilled or tap water to make it less salty. If you have added too much fresh water, the hydrometer will sink below the 1.025 mark. In general, you will find that most ocean animals will stand water fresher than normal better than water that is too salty.



When a hydrometer is put into ocean water, it usually floats at the 1.025 mark. If the water gets more salty, the hydrometer floats higher—a reminder to add some fresh water.

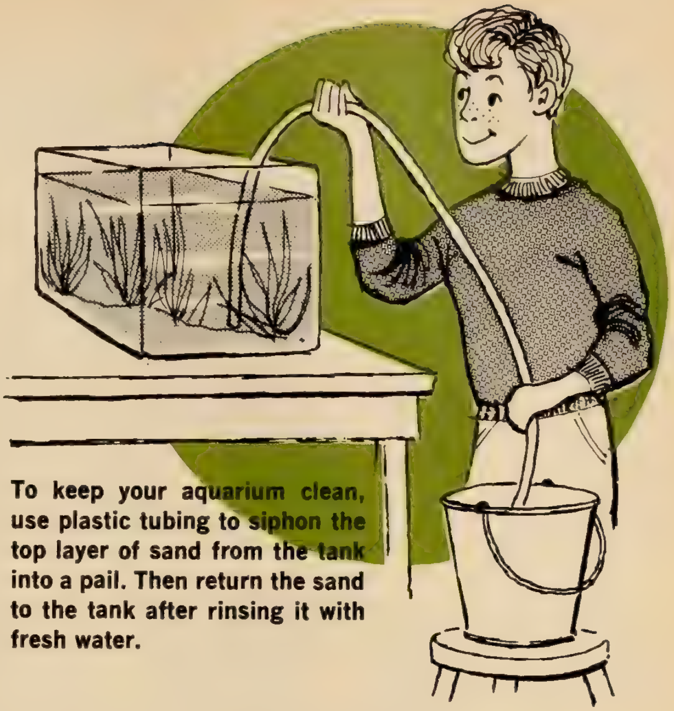
Even when you use a filter, your salt water aquarium will need some cleaning. To keep algae from growing, you should wipe the inside surface of the glass with a clean rag or glass wool (and be sure your hands are clean).

Take out the top layer of sand once in a while, rinse it with fresh water, and return it to the tank. This is best done with a section of plastic tubing about a half inch in diameter and about four feet long. Use it as a siphon. First fill the tubing with water by holding both ends under the faucet, then hold the ends shut with your thumbs. Put one end into the tank where the sand is to be removed and the other end into a pail placed below the bottom level of the tank (*see diagram*). You can control the removal of dirty sand by keeping your thumb at the tube end in the pail, ready to shut off the flow. Control the pick-up end in the tank with your other hand. If you have enough bottom-feeding animals and sand-burrowing animals, this chore need not be done very often.

Feeding and Watching

You will need at least 10 or 15 minutes daily to prepare food and give it to your animals. Then, an hour or two later, you will need another five minutes to remove any uneaten food—to prevent pollution.

Some of the animals you may have, such as nudibranchs, periwinkles, and sea urchins, are algae eaters. Most of the other sea animals you'll have are likely to be meat-eaters. Many of them will eat tiny bits of chopped clam, shrimp, or fish. Very small earthworms (or cut up pieces) make good food. Others will want live food. You can often buy live tubifex worms, daphnia, blood worms, and adult brine shrimp from aquarium supply stores. Barnacles and small sea anemones will eat newly-hatched brine shrimp. You can buy the brine shrimp eggs and hatch them yourself. You may have to do some experimenting before you find the food that best suits your animals. That is why you should take your time, sit down, and watch what happens after you put the food into the water. You may find that one large crab is eating everything in sight!



To keep your aquarium clean, use plastic tubing to siphon the top layer of sand from the tank into a pail. Then return the sand to the tank after rinsing it with fresh water.

It is wise to take a few minutes each day to watch your aquarium for another reason. You should become familiar with the normal actions of each animal in the tank. If an animal shows signs of distress, put it in a separate container. Watch closely because some ocean animals move very little, and any dead animal can pollute the water.

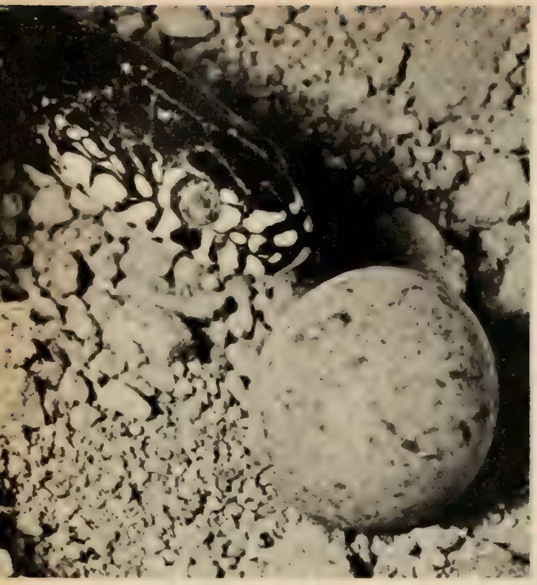
If, despite your best efforts, you wake up some morning and find the water cloudy, don't despair. First, try to find the source of pollution and remove it. Then use extra filters (it's good to have one or two extras for just such emergencies). If you have extra salt water, now is the time to use it. Usually, by replacing one third of the water and adding extra filters, you can clear up murky water in two or three days with little or no loss of life.

There is much to be learned about many kinds of salt water animals. Try keeping careful records on some of yours. For example: How do they eat their food? How much do they eat? Do they shed their skins? If so, how often? How long do they live? How do they act toward other animals? You may discover some information that will help others who keep salt water aquariums ■

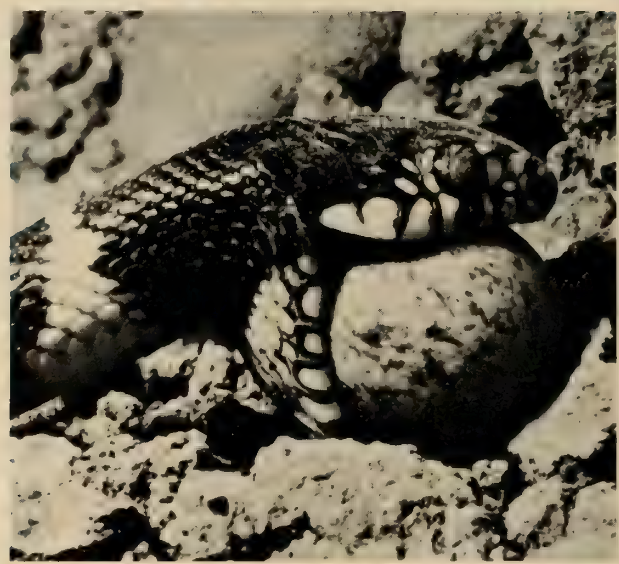
■ These magazines and books will help you set up and care for an aquarium, and identify the animals you collect: **The Aquarium Magazine,** 51 East Main Street, Norristown, Pa.; **Salt Water Aquarium Magazine,** P.O. Box 59-2214, Miami, Florida; **Seashores,** by Herbert Zim and Lester Ingle, Golden Press, N.Y., 1955, $1 (paper); **Field Book of Seashore Life,** by Roy W. Miner, G. P. Putnam's Sons, N.Y., 1950, $8. **1001 Answers to Questions About the Seashore,** by N. J. Berrill, $1.75 (paper), and **1001 Answers to Questions About Aquarium Fishes,** by I. M. Mellen and R. J. Lanier, $2.95 (paper), both published by Grosset and Dunlap, N.Y.

swallowed by
Snak

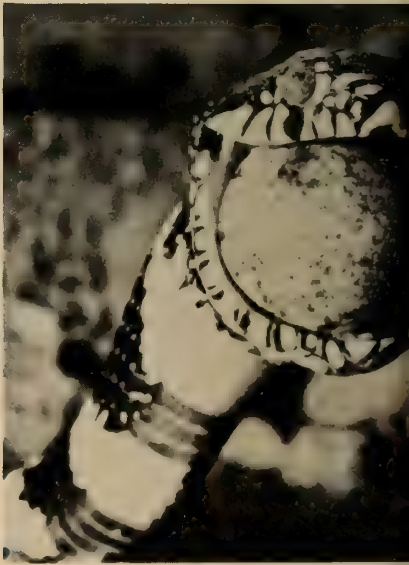
Text and
photograp
by Robert H. W



1 A small king snake discovers a sparrow egg. The egg is about twice the size of the snake's head.

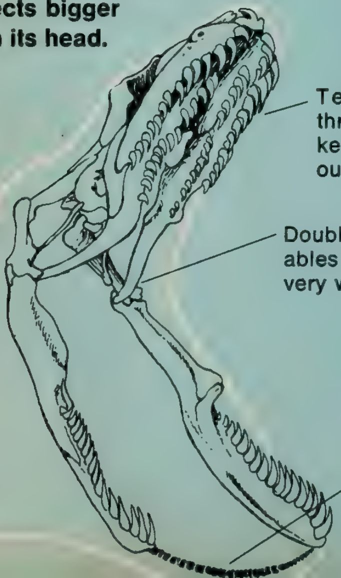


2 Starting with the small end first, the snake begins to swallow the egg. Notice how far the lower jaw of the snake has gaped open.



3 Now the egg is entirely in the sna
The lower jaw has spread wide,
to fit the egg it grips.

This diagram shows how a snake's jaws, muscles, and teeth enable it to swallow objects bigger than its head.



Teeth curved toward throat help grip the food, keeping it from slipping out of mouth.

Double-jointed hinge enables snake to open jaws very wide.

Elastic muscles and ligaments allow two halves of lower jaw to spread apart.

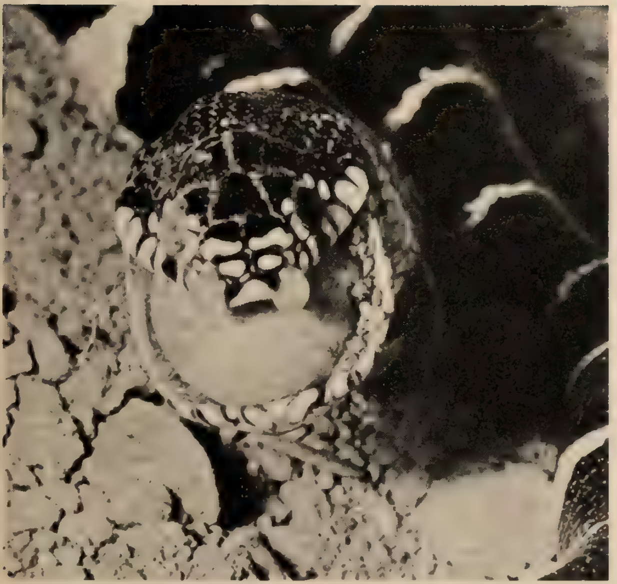
■ Think of an animal swallowing—all at once—a piece of food twice the size of its own head. That would be like a man swallowing a watermelon—impossible. But it is a fairly simple matter for a snake.

Since snakes have no feet, hands, or other limbs, they have no way of holding food and tearing it into small pieces. They must eat it all in one piece. They are able to do this because their bodies—and especially their jaws—are very flexible.

The two halves of a snake's lower jaw are not joined together solidly in front, as in humans. Instead, the two halves are held together by stretchable muscles and ligaments (see diagram). The lower jaw bones are also attached to the snake's skull at a double-jointed hinge that allows the jaws to open even wider.

Snakes have no way of pushing food into their mouth, so they pull it in. First, sharp teeth grip the food. Then the upper and lower jaws on one side of the head hold the food while the jaws on the other side reach forward and get a new grip. Then those jaws hold the food while the other side reaches forward. The jaws "walk" forward around the food—as you might pull on a tight-fitting sock. Once in a snake's throat, the food is pushed along to the stomach by strong muscles. The food often shows as a swelling in the body.

The photos on this page show a king snake eating a sparrow egg. You may be able to watch a snake eating by visiting a zoo at feeding time. Snakes usually eat only about once a week or so, however, so you might check with the zoo beforehand to find out when the snakes are fed. (Or perhaps you already know someone who has a pet snake you could watch.) ■

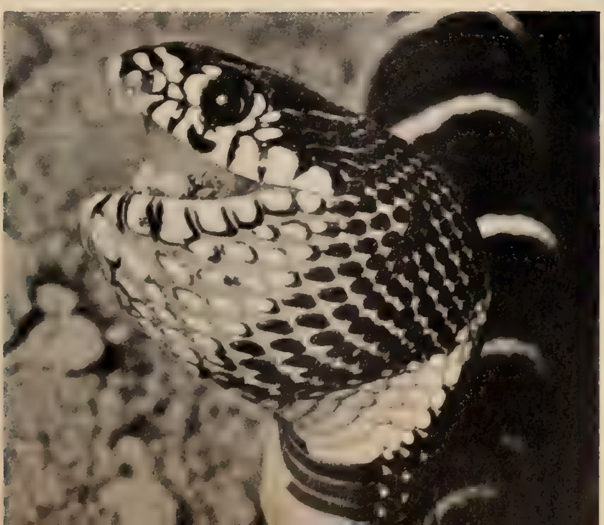


4

For 12 minutes the snake gradually moves its jaws forward around the egg shell. Then, when the egg is almost swallowed, the shell breaks and some of its contents run out of the snake's nostrils. Snakes usually are able to swallow eggs whole.

A PUZZLER

The unusual jaws of snakes are an example of an *adaptation.* An adaptation is a characteristic of an animal, such as a part of its body or a way of behaving, that helps the animal survive in its surroundings. It may have taken millions of years for the jaws of snakes to reach the form they have today, as they changed gradually through many generations. Can you think of ways in which other animals are adapted for getting food? What about the beaks of different kinds of birds? Do some animals have special ways of behaving that help them get their food?



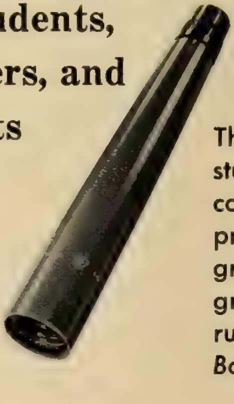
5

The snake tilts its head back and swallows the broken egg. The shell will be digested along with the egg white and yolk. (Some egg-eating snakes eject the bits of shell and just digest the yolk and white.) In this photo, notice how the skin is stretched around the lower jaw. The scales are separated, showing the skin underneath.

brain-boosters

CONTEST

for Students, Teachers, and Parents



YOU CAN WIN A TELESCOPE OR MICROSCOPE

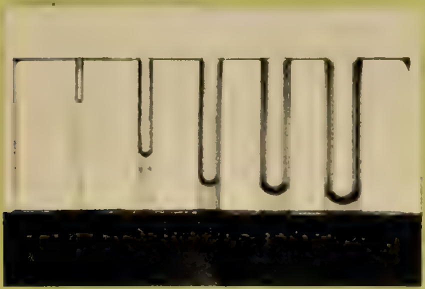
To enter the contest, send the answers to the Brain-Boosters below to:

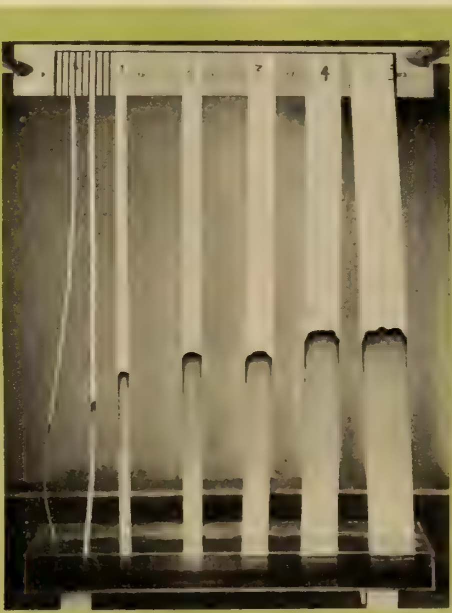
Mr. Brain Booster
Bedford Lane
RFD #2, Lincoln, Mass. 01773

Answers must be mailed by November 14, 1966. *Be sure to include your address, age, and grade in school.* The names of the winners and some of their answers will be published in the February 20, 1967 issue of *Nature and Science.*

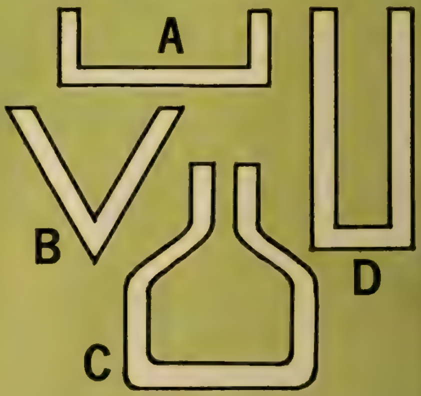
The first prize is your choice of a 10-power or a 100-power student microscope or a 10-power telescope (*see photos*), courtesy of Bausch & Lomb Incorporated. Five of these prizes will be awarded, one to the winner in each grade group: 4th grade and below; 5th grade; 6th grade; 7th grade and above; teachers and other adults. The three runner-ups in each group will receive copies of *Brain Boosters,* a new book by Mr. Brain Booster himself.

1. The photograph below shows how water rises up thin *capillary* tubes. Notice that the water goes highest in the thinnest tubes. In the photograph on the right, blotters of different thicknesses are held in a tray of water. Here the water rises highest in the thickest blotter. Why?



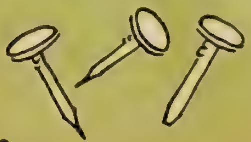


5. Suppose the four containers pictured below were put out in a rain storm. Which container would collect the most rain water? In which one would the water be deepest?



2. Why doesn't a ball point pen write when the point is higher than the rest of the pen?

3. Why is the U.S. rocket launching site located in Florida rather than in Arizona or California?



4. Why do sharp nails split wood more often than blunt nails?

6. There is a blackout at 5:30 in the afternoon. The next morning you notice that an electric clock says 3:30 when it is 11:00 by your wristwatch. How long was the electricity off, and when did it go back on?

Turn the following page for answers to Brain-Boosters in the last issue.

Has "Lost Atlantis" Been Found?

BY STEVEN W. MORRIS

The tale of a great empire that sank into the Atlantic Ocean has been repeated for centuries, by storytellers of old as well as by modern magazines and movies. Scientists may have discovered Atlantis (but not in the ocean).

■ You may have heard or read about the lost land of Atlantis as a kind of fairy-tale place that never really existed. But some modern-day scientists, using electronic equipment as their "eyes," think they may have found proof of where Atlantis was.

The story has it that thousands of years ago, long before the time of the Romans, the rich and powerful nation of Atlantis tried to conquer the world. Its armies and ships fought against Greece and won. It had colonies in North Africa and Italy. Then, one day, the earth shook under Atlantis. A gigantic earthquake toppled its buildings and killed its people. The sea around Atlantis rushed across the land and swallowed it.

Is It True?

This tale has been told for many centuries. Maps have been drawn showing different places where the sunken land of Atlantis must be. But is the story true? The story of Atlantis is not one story but a jigsaw puzzle of many stories. The most complete one was written by the Greek thinker Plato, who lived about 2,400 years ago. Plato based his story on another description of Atlantis that his ancestor Solon wrote 200 years before Plato was born. Solon got much of his information about Atlantis from the writings of Egyptian wise men.

Plato wrote that Atlantis was an island nation in the Atlantic Ocean. A *moat,* or large ditch of water, surrounded the center of the main city where the royal palace stood. Atlantis first belonged to the sea-god Poseidon, who divided the land among his 10 sons and made them kings. After many, many years, the people of the island became dishonest and evil, and then the island was destroyed. Today many historians agree that the Egyptian story of Atlantis–the story that was told to Solon—was based on a great explosion and tidal wave sometime in the past. The explosion and tidal wave were so huge that the Egyptians thought a continent must have been destroyed.

The Wrong Sea?

Plato wrote that a plain surrounded the main city of Atlantis, and that it was divided into 60,000 lots which were 10 *stadia* long and 10 stadia wide. (A stadium was a measure of length that varied from 607 feet to 738 feet.) If we take 607 feet as the length of the stadium, and multiply the area of one lot by 60,000, we find that the area of the plain was at least 80,000 square miles. If all 10 kingdoms were about the same size, the whole of Atlantis must have been 800,000 square miles–three times the size of Texas.

A land so large could not have been an island in the Mediterranean Sea, which is only 1,145,100 square miles

(Continued on the next page)

This photo from the movie "Atlantis, the Lost Continent" shows how lava from an erupting volcano may have destroyed the main city of this ancient nation before it sank into the water more than 3,000 years ago. The wall at the bottom is the outside edge of the moat that was said to have surrounded the city. Scientists believe they have found traces of this moat in the sea bottom around the island of Thera, in the Aegean Sea (see *map on the next page*).

in area. The only body of water the Greeks knew about that was big enough to hold such a piece of land was the Atlantic Ocean. That is why searchers for Atlantis have always looked in the Atlantic.

However, scientists recently have suggested that the size Plato wrote down for Atlantis may be far too large. Dr. Anghelos Galanopoulos, an earthquake scientist at the University of Athens in Greece, has said that Solon, gathering information for his original story, may have thought the Egyptian number for 100 meant 1,000. As an example of how this could happen, the professor points out that today when an American or Frenchman says a "billion" he means a thousand millions (1,000,000,000); but when an Englishman says a "billion" he means a million millions (1,000,000,000,000). If Solon made this kind of mistake, his description would have made Atlantis 10 times bigger than the Egyptian records said it was. Dr. Galanopoulos divided the size that Solon and Plato gave for Atlantis by 10, and got 80,000 square miles as the size of Atlantis. A land this size could easily fit into the Mediterranean and Aegean Seas.

A Gigantic Explosion

Solon had written that Atlantis was destroyed 9,000 years before his time. Dr. Galanopoulos divided this number by 10 and got 900 years. Since Solon lived about 600 B.C., this new number puts the destruction of Atlantis somewhere around 1500 B.C. Does this date give any clues to where Atlantis might have been? Dr. Galanopoulos says yes.

The scientists know that a gigantic volcanic *eruption,* or explosion, once took place on the island of Thera (*see map*), about 1400 B.C. They figured out about when the explosion occurred by measuring the amount of *radioactive decay* in pieces of wood that had been covered with ashes by the explosion. (Radioactive decay means the change of certain kinds of atoms in the wood into different kinds of atoms. By measuring how many atoms of each kind are now in the wood, scientists can figure out about when the wood was cut from a tree.)

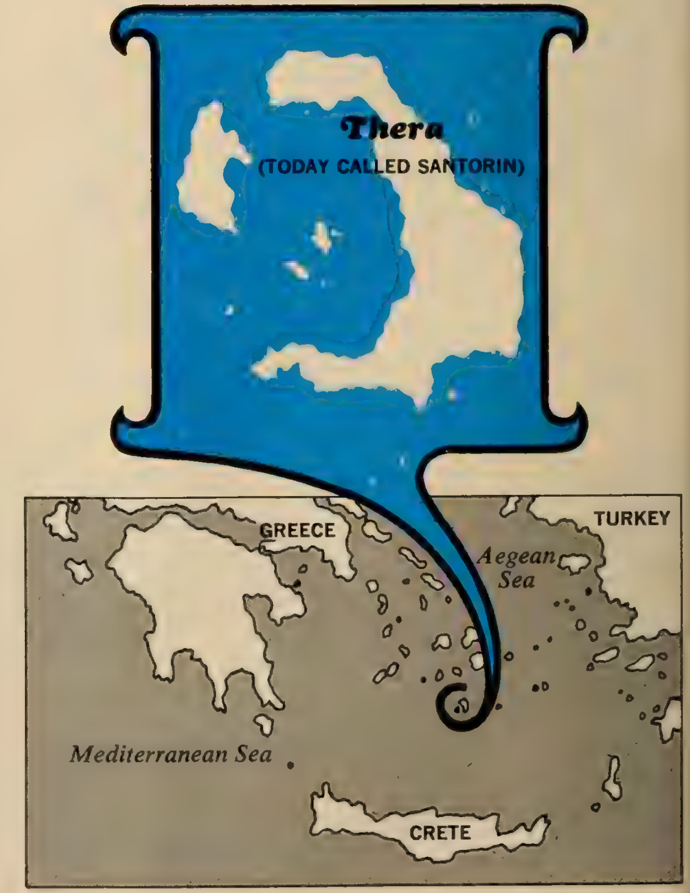
Most of the island sank into the sea, leaving a half-circle of land, about 11 miles across, above water. The explosion, and the ashes that fell from the air after it, destroyed the cities and towns of the rich, powerful Minoan people who lived on Thera and on the large island of Crete. Before that time the Minoans had conquered most of Greece and all the islands in the Aegean Sea. Could the Minoans have been the legendary people of Atlantis?

A Drowned Moat

In August 1966 Dr. Galanopoulos went with a team of Greek and American scientists to Thera to test this idea. The leader of the team was Dr. James W. Mavor of the Woods Hole Oceanographic Institution in Massachusetts. The scientists wanted to see if they could find any of the landmarks Plato had described in his story. They sailed aboard the research ship *Chain,* which belongs to the Woods Hole Institution.

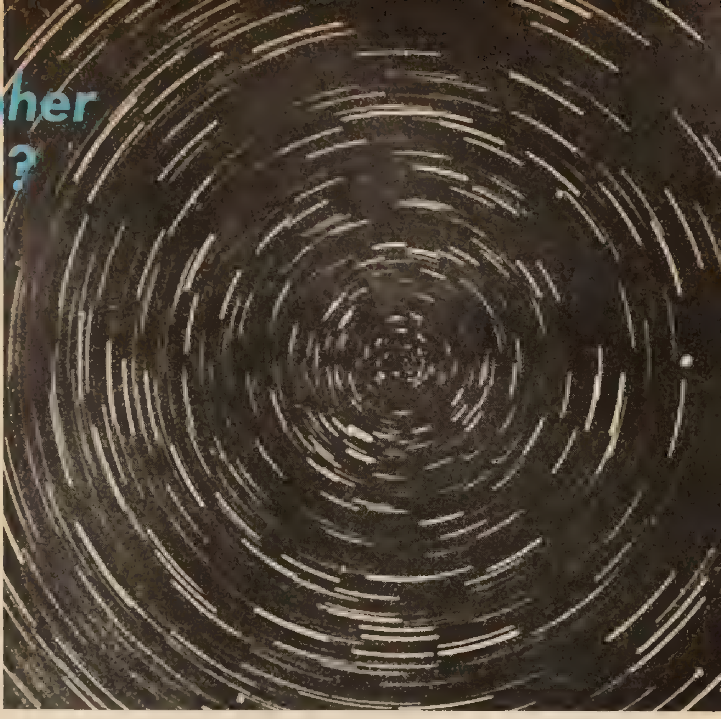
The *Chain*'s electronic equipment bounced sound waves off the sea bottom as the ship traveled in the waters around Thera. When the scientists read the picture these sound waves produced on their equipment, they got a surprise. At a place where the water is 1,300 feet deep they saw the outline of a wide ditch that is buried under a thick layer of volcanic ashes.

Could this ditch be the moat that Plato said the men of Atlantis built around the center of their capitol city? Dr. Galanopoulos thinks it is. Dr. Mavor said that this and other shreds of evidence make him think the Minoans were the people of Atlantis. But it's too early yet to be sure. More and better measurements of the moat and the surrounding area have to be made. Dr. Mavor and Dr. Galanopoulos plan to return to Thera next year to continue the search for lost Atlantis ■

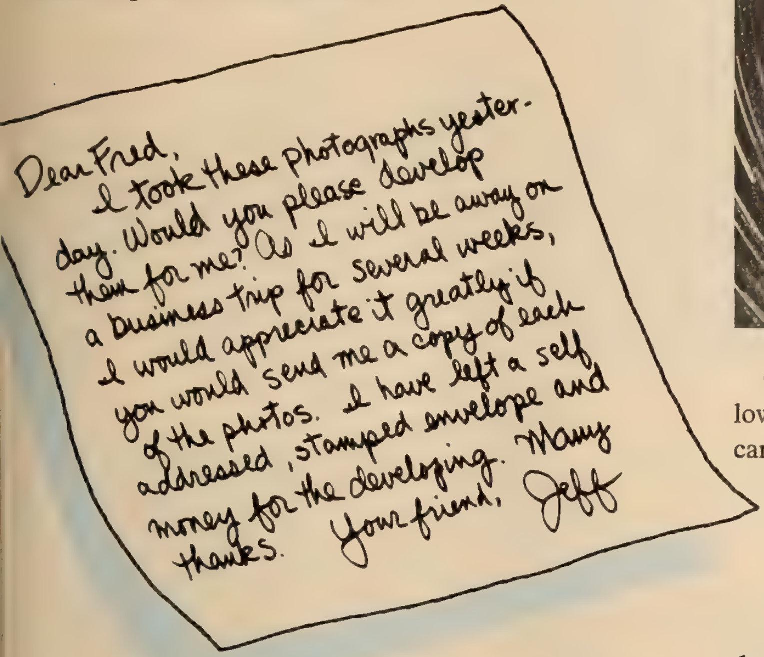


Scientists think that Thera Island is the top of a submerged volcano that exploded and destroyed Atlantis.

Can you help a photographer take a picture like this?



■ The life of a photographer is not without its mysteries. A photographer we know, Fred Flicka, was recently called out of town for a day. Upon returning to his studio, he found the following note attached to a roll of film which had been placed in his mailbox:



Dear Fred,
I took these photographs yesterday. Would you please develop them for me? As I will be away on a business trip for several weeks, I would appreciate it greatly if you would send me a copy of each of the photos. I have left a self addressed, stamped envelope and money for the developing. Many thanks.
Your friend, Jeff

Mr. Flicka developed the film as his friend had asked. When he finished, one of the photographs caught his attention. The photograph is reproduced on this page.

Mr. Flicka was puzzled! In spite of his many years of experience as a photographer, a number of things bothered him. Most of all, he wondered what the photograph was of and how it had been taken.

Can you help Mr. Flicka? If so, copy the questions below on a sheet of paper and answer them as well as you can. Send your answers to:

Mr. F. Flicka
805 West Pennsylvania Avenue
Urbana, Illinois 61801

QUESTIONS

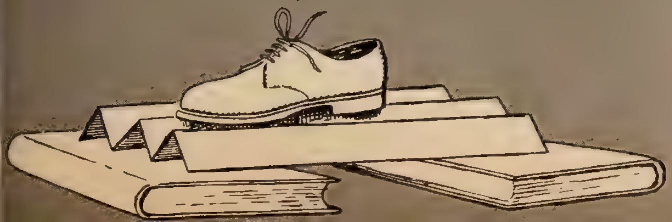
1. **What did Jeff photograph?**
2. **Why do you think your answer is correct?**
3. **How can the appearance of the photo be explained?**
4. **Mr. Flicka wants to take a photograph similar to the one his friend took. How could he do this?**

(The answers to these questions will be published in a future edition of *Nature and Science*.)

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The cells from the ripe banana are those that have little or no dark spots. The numerous dark blobs in the cells from the unripe banana are starch granules, turned purple by the iodine stain. As a banana ripens these starch granules change into sugar. Why shouldn't bananas be kept in the refrigerator?

Can you do it? You can support a shoe on a piece of paper between two books by folding the paper into a fan.



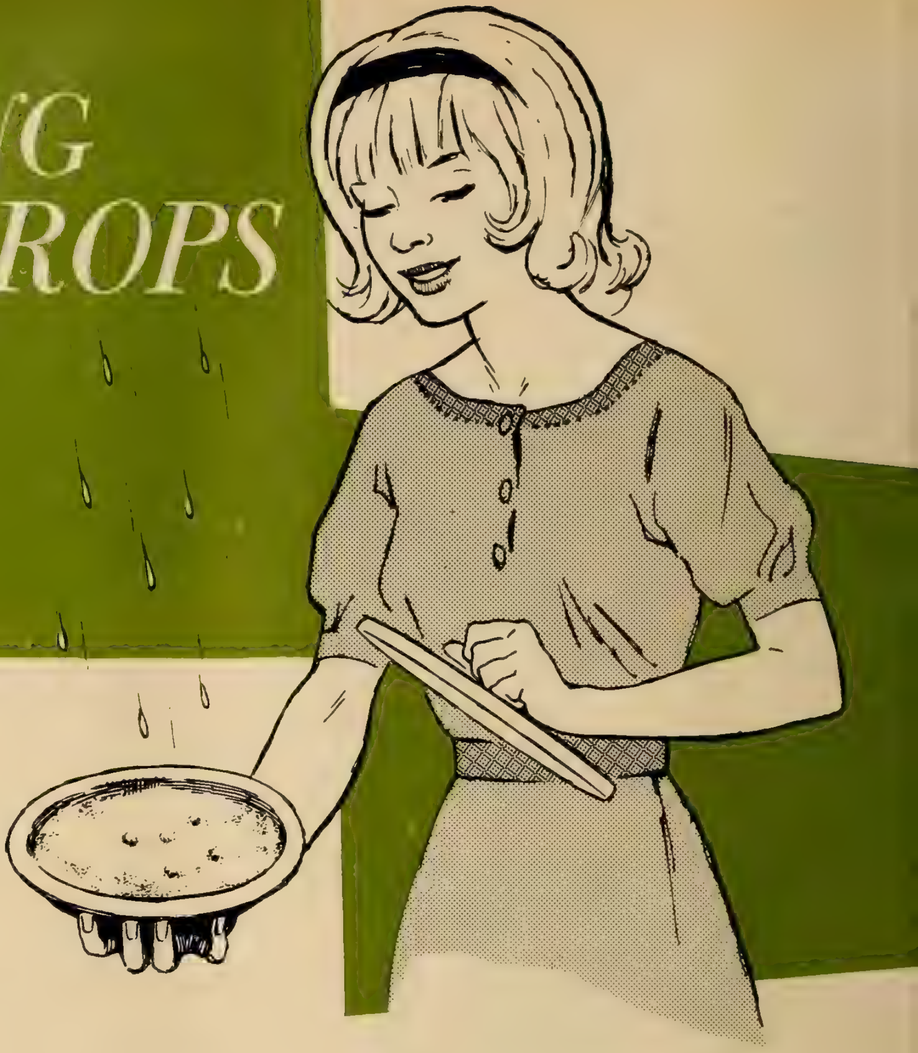
What will happen if . . . ? A thermometer frozen in ice will not break, and will indicate the temperature of the ice. Is ice in your freezer 32°F, or does it get even colder?

Fun with numbers and shapes: These numbers are arranged alphabetically according to the way they are spelled. **8 5 4 9 1 7 6 3 2 0.**

For science experts only: The rubber in a balloon is most difficult to stretch when the balloon is small. (This is why it is hardest to get a balloon "started" when you begin to blow it up.) If a large and a small balloon are connected, most of the air from the small balloon will go into the larger one. This is because the air in the small balloon is being squeezed more, and gets forced into the larger balloon.

MEASURING RAINDROPS

by Duncan C. Blanchard



This isn't as silly as it sounds. Scientists are counting the drops of different sizes to find out more about how rain is made. You can measure raindrops, too.

■ Did you know that you can take the fingerprints of a rainstorm? Just as human fingerprints distinguish one man from another, raindrop patterns can tell us a great deal about different kinds of storms. I'm going to show you some simple ways to make a raindrop record, and then you try to answer some questions about them. How big are raindrops? Are they all the same size? Are the drops at the beginning of a storm bigger than those at the end?

People have always been curious about how the rain is made. Two thousand years ago, they thought one of the causes of rain was the wind pressing against "swollen clouds." And they believed lightning and thunder happened when clouds bumped together and made sparks and noise, just as when two stones are struck together.

Today those ideas seem funny to us. Scientists have much more accurate information about what causes the rain and what the raindrops are like. They use high-speed photography to stop the motion of falling drops in mid-air and study their shape and size. They go up in airplanes and climb mountains to take samples just as raindrops leave the clouds.

Flour-Coated Raindrops

But even without a high-speed camera or an airplane you can measure the size of the raindrops. You can do it the same way a man named Wilson Bentley did about 70 years ago. Bentley was a farmer who lived in the small town of Jericho, Vermont. Although he had little formal education and was busy with his farming, he was able to carry out many studies on the mysteries of rain and snow. In the year 1898, he began his studies on rain. Over seven years he made 344 measurements of the sizes of raindrops from many different storms.

How did he measure the raindrop size? Very simple; he let the rain fall into pans of fine flour. The raindrops did not splash because each drop absorbed the flour and pro-

Copyright © 1966 by Educational Services Incorporated. This article is adapted from the forthcoming Anchor Science Study Series book From Raindrops to Volcanoes, *by Duncan C. Blanchard, to be published by Doubleday & Company, Inc. in the summer of 1967.*

duced a small pellet of flour and water. Bentley let the pellets dry and then measured their diameters.

All you will need to try Bentley's experiment is a pie pan (or a paper plate that has sides), a cover for the plate, a flour sifter, some flour, a ruler, paper and pencil. Put about an inch of flour in the plate. The next time it rains, cover the plate and take it outside. Hold it in the rain, remove the cover, and let the rain fall into it for about three seconds. You can tell when the time is up by counting one-thousand-and-one, one-thousand-and-two, one-thousand-and-three. Cover the plate as soon as the three seconds are up. This way you can be sure that more than one drop doesn't land in the same place.

When you get indoors, look at the flour. You will see a number of wet, round lumps made when the drops hit the flour. Let these lumps dry for at least two or three hours, or bake them in an oven. Then use the flour sifter to remove the hardened balls from the flour. Now you are ready to measure them with the ruler.

How do you know that the flour balls are the same size as the raindrops? Bentley did other tests to find out if the flour pellets were really the same size or were actually bigger or smaller than the drops. He made artificial rain by suspending drops of water from pieces of glass or wood and letting them fall from different heights into the pans of flour. In this way, he could compare the size of the drop and the size of the pellet. He found that the smaller drops made pellets of almost exactly the same size. The larger drops produced pellets that were somewhat flattened by the impact of hitting the flour and were about one-third larger than the original drops.

Wilson Bentley wrote a wonderfully clear and interesting paper on what he had found out about the rain. But no one carried on with his investigations until about 40 years later. Then two scientists used his flour method to take more measurements of raindrop size. Since that time scientists in many parts of the world have used the flour and other methods to discover much more about the sizes of raindrops.

Other Ways To Measure Raindrops

One scientist in Germany used sheets of paper that soaked up the drops as they fell. He could then measure the size of the spots and compare them to the size of the original drops. You can take measurements this way by getting some ordinary filter paper (the round paper filters used in some coffee pots will do). Expose the paper to the rain for two or three seconds and then, when you get back indoors, take a pencil and circle the wet spots made by the drops. You can measure the wet spots or wait until the spots dry and measure their pencil outlines.

A better way is to dust the filter paper lightly with a dye that dissolves in water. The spots from the raindrops will then be permanently recorded on the paper. You can get a dye called methylene blue powder from some drugstores. (A fabric dye such as Tintex will work nearly as well.) Be very careful with the dye, because if some of it gets on you, the spots will be recorded on *you* as well as on the paper. You might wear an old pair of gloves while working with the dye.

Treat the papers by putting them one at a time into a large jar in which one or two teaspoons of the dye have been placed. With the cover on the jar, turn it around so that the powder tumbles completely over one side of the paper. Remove the paper from the jar and shake off any excess dye by snapping the back of the paper with your fingers. Afterward the treated side of the paper may not appear to have any dye attached to it, but it does. You will find out when you expose it to the rain. This method is much better for taking measurements in a light gentle rain than in a heavy rain. Why do you think that is so?

Another way to measure raindrops is with a nylon screen made from some old nylon stockings, two embroidery hoops, and confectioner's sugar (the very fine, powdery kind of sugar). Go to the dime store and get a set of embroidery hoops. Pull a piece of the stocking tightly on the hoops and coat it with the sugar (*see photo*). Shake off any loose sugar before you expose your screen to the rain. That's all there is to it. You're now ready to go out and measure raindrops.

One word of warning. The sugar may not stick at all well to stockings that are new. It seems that old, worn stockings carry the natural body oils that make the sugar stick. So be sure that someone has "worn them in" first. The sugar screen method will give you very nice raindrop

(Continued on the next page)

HOW DOES WIND AFFECT YOUR SAMPLE?

Wind can influence how raindrops fall. Even though it may not cause the drops to break up, the wind can separate the drops according to size. You can demonstrate the basic idea to yourself. Take a handful of dirt or sand and throw it a few feet into the air when a light breeze is blowing. You will find that the larger particles will fall back very rapidly and strike the ground nearby. The smaller particles move along with the breeze to hit the ground much farther away. In the same way, wind can sort out raindrops as they fall to the ground.

Measuring Raindrops (continued)

patterns. It is especially good for measuring the very large drops that fall in thunderstorms and heavy rains. Such drops will splatter in the flour and will make the filter paper look just as if it had been held under an open faucet.

What To Look for

Count the number of drops on your screen or paper from measurements made in a light rain and in a heavy rain. You will probably find that a heavy rain produces bigger and more drops than a light rain. Now of course anyone who has walked in the rain could make this statement. But without measurements such as you have made, probably no one could guess that the number of raindrops per cubic yard of air varies from about 1,000 in light rains to 5,000 or more in the heavier rains.

So far, no one knows for certain exactly how raindrops are formed in a cloud, but investigations such as the ones suggested below are helping scientists to find out ■

INVESTIGATIONS

1 Are all your raindrops the same size? If not, how big are the largest and smallest drops that fall? The size of raindrops has been found to range all the way from 1/125 of an inch in diameter to drops of about 1/4 inch in diameter. Keep records of your findings. Are there generally more small drops or more large drops in an average rainstorm?

2 Try catching some raindrops near the beginning, near the middle, and near the end of a rainstorm to see if they differ in size. Instead of measuring each of the drops, you might separate them into three groups—big drops, medium drops, and small drops. Keep a record of the number of each kind you find in a storm on a chart like the one below, and compare the record of one storm with that of another. Do some storms produce bigger raindrops than others?

Date	Time	Outdoor Temperature	
SIZE OF RAINDROPS	BIG DROPS	MEDIUM DROPS	SMALL DROPS
Number of drops at beginning of storm			
Number of drops in "middle" of storm			
Number of drops near end of storm			

RAINDROP MEASURER

Duncan Blanchard decided when he was a young boy that he would be an artist. Then by accident he read a book that started him down an entirely different path. The book was called *Men of Science,* and he found it lying by a road in Guam where he was on naval duty during World War II. He read it and was impressed by the stories of scientists of the past. He decided to be a scientist himself, and that was the beginning of his studies of raindrops, bubbles, volcanoes, and other forces that shape our atmosphere. His investigations have taken him to many places—Hawaii, the Caribbean, Costa Rica, and Iceland, as well as to his present position as a weather scientist at the Woods Hole Oceanographic Institution of Massachusetts.

Standing inside a large blimp hangar, Dr. Blanchard prepares to catch drops on a sugar-coated nylon screen as man-made "rain" begins to fall from a fire hose atop the hangar (top photo). The photo of the screen shows the pattern made by the man-made drops, which were measured for comparison with drops in a real rainstorm.

Using This Issue...

(continued from page 2T)

and earth sciences are involved in this study, with a number of experiments your students can do on their own. (*See also page 4T, Advanced Teacher's Edition.*)

To those of you who receive only the regular edition: By measuring raindrops as suggested in the SCIENCE WORKSHOP article, your pupils can find out something about the differences in raindrop sizes.

Activity

Ask your pupils to draw pictures of raindrops falling through the air. They will probably draw "tear-shaped" drops, with fat, round bottoms and pointed tops. Then have them turn on a faucet, just enough so that the water drips out drop by drop. Have them watch a single drop as it moves from the faucet to the drain.

They should be able to see that the drop is "tear-shaped" only when it breaks away from the water in the faucet. Then it quickly takes on the shape of a hamburger bun. (Air is pushing against the bottom and sides of the drop and surface tension tends to pull the drop into the smallest possible shape.) Have them see if a drop of water running down one's face is "tear-shaped."

……

They Mean What They Say . . .

(continued from page 1T)

three balloons: one filled with air, one with carbon dioxide, one filled with helium; all blown up to the same volume. What might he then say about flotation? We've known third graders (in Jeremy's class) from a low socioeconomic district to say that "Gravity pulls the air more than it does the helium, so the air pushes the helium up."

What Makes the Wires Hot?

Let's now listen to Karen. Karen was in the sixth grade class, which had been experimenting with batteries and bulbs. Her wires became hot and she was fascinated with this feature. "They got hot because they were light; they didn't when they were heavy." Sounds all right if we substitute wire diameter for "heavy" and "light." (Thin wires offer more resistance to the electrical energy than thick wires of the same material.)

"Tell us about it," we encouraged. "Well, this wire," Karen held up the insulated piece," is covered with a black layer and an orange layer, and it doesn't get hot. It doesn't get hot when it's heavy. But this one," she held up a skinned wire, "gets very hot." Another pupil,Sarah, suggested that the covered wire might also be hot, but you couldn't feel it through the covering.

At the next session, Karen and Sarah worked together. They were given wires with different kinds of insulation (cloth, plastic) and bare copper wires of different diameters. After this experience, the girls decided that the coverings prevented one from feeling the heat, and that the metal was the important part for the electricity to go through. They found too, that the very thin wire got hot enough to melt. Other children in this class discovered that "Wires don't get hot if you have a light in the circuit, but the wire inside the light bulb gets hot enough to glow. There's a very thin wire in the light bulb," they added in confirmation of Karen's problem.

These sixth graders had been given no information by the teacher during the three experimental sessions and discussions. The meaning of the materials changed for them during the process of exploration and discussion. Each time they said what they meant. Each time what they said became richer in meaning.

Building a Concept

A group of fourth graders was watching a desert terrarium in which an iguana (a kind of lizard) buried itself under the sand. "How does it breathe under there?" asked Dorothea. "I know!" said Edward, and he leaned heavily on his elbows placing his cheeks between his hands. His words came slowly, with many hesitations.

"You need oxygen to breathe . . . water is H-two-Oh, so it has oxygen. Fish have gills to breathe oxygen in water. Rocks must have oxygen . . . so lizards must have sort of gills to breathe oxygen from rocks."

This is seemingly a strange kind of reasoning and we might tend to dismiss it as something a normal adult couldn't cope with until we realize the meaning behind this kind of thoughtful explanation.

An early stage in building concepts is finding hidden likenesses. We notice that many different things are colored green, and green begins to assume an existence independently of the things that are green. We notice triangular shapes in the face of a mouse, in the delta of a river. Edward was putting things together through a common attribute, or likeness, but he did this in sequence, changing the attribute with each addition.

Breathing is linked to oxygen, oxygen to water. Water and its oxygen (no separation of the ideas that oxygen is part of the molecule of water and can also be dissolved in the liquid) are linked to breathing by gills. Gills are used for breathing oxygen from strange places, so rocks must have oxygen and lizards must have gills to breathe it. No doubt the similarity of the shapes of lizards and fish played something of a perceptual role. But Edward actually said what he was thinking. He meant what he said, but he didn't explain all the meaning that went behind the words. Indeed, he couldn't know these meanings.

Complex Thinking

This process of thinking by associating attributes is called *complex thinking*, or thinking in complexes. (Complex thinking is well presented in *Thought and Language*, by L. S. Vygotsky (Massachusetts Institute of Technology, Cambridge, Mass., 1962, $7.50; paperback, $2.45). When the linking attribute is constantly changed it is called *chain complex thinking*. It is a legitimate stage on the road to building concepts.

It may be a relief to know that *we* no longer have to explain the why's of science, but it is just as difficult to climb into the minds of children to see what they mean by their sayings. Until we do that we cannot help their thinking develop by giving them appropriate new materials. However, I happen to think this latter role is much more fun than "explaining;" it is also much more rewarding because it develops thinkers. I hope you will like to try it ■

(N&S articles about approaches to science teaching are not meant to imply endorsement of any particular approach by The American Museum of Natural History.)

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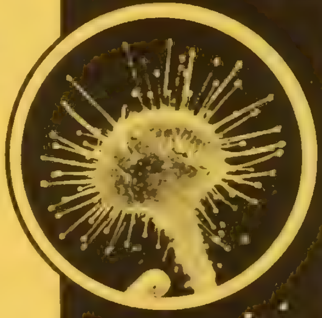

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RST-6

nature and science
TEACHER'S EDITION
VOL. 4 NO. 5 / NOVEMBER 14, 1966 / SECTION 1 OF TWO SECTIONS

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Probability and Your Pupils

by Nancy Kent Ziebur

■ There is very little in our lives that is both important and simple. Most of the decisions people face are not questions of all right or all wrong, all good or all bad. They usually involve those vast gray areas in which we must make the best possible use of incomplete knowledge to help us arrive at a choice which may be satisfactory.

It is becoming more and more important for children to understand that even when there is no simple answer to a problem, one's course of action is not necessarily restricted to either guessing or giving up. Many complicated problems can be handled very well indeed if we get help from our knowledge of probability. This is true in economics, business, politics, and social relations, as well as in technology and the sciences.

The article "A Matter of Chance" in this issue of *N&S* will introduce your pupils to some basic ideas of probability. Here are some others you might discuss with your pupils in addition to the topics suggested on page 2T.

Probability and Science

Probability is involved in the interpretation of every scientific experiment. Each experiment or observation is only one of many trials that could be repeated. We cannot know in advance that a second experiment will give the same result as the first. But after, say, 50 observations are made, we may have a pretty fair idea of the range within which later results will fall. Sometimes a sample of many more than 50 is necessary to provide information that is as accurate and reliable as desired.

The choice of *sample size* will depend largely on three factors:

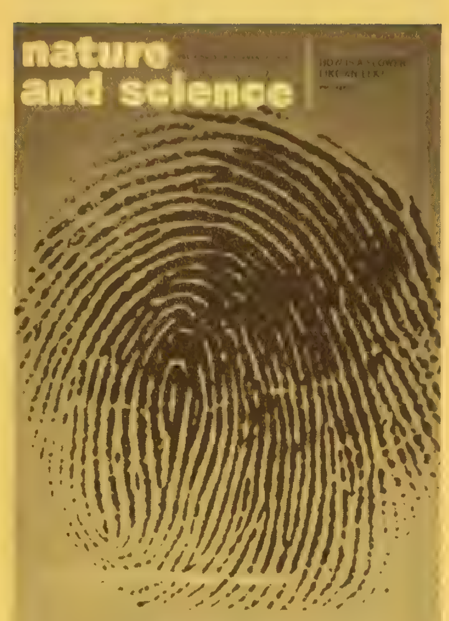
1. *The variation among observations.* You might ask your pupils whether they would have to weigh more dogs or more cats in order to make reliable estimates of the average weight of adult dogs and of adult cats. Do dogs come in many sizes? Which breeds are small, medium, large? Do cats vary as much in size? Fewer cats would be needed, because there is less variation in size among cats than among dogs.

What similar examples can your pupils suggest? To estimate the average size of oranges in a sack, fewer would have to be measured than if one wanted comparable information about potatoes. To estimate the average weights of different kinds of athletes, we would need to weigh fewer jockeys than football players. In estimating average heights, we would need to measure fewer card tables than refrigerators.

2. *The degree of reliability required.* Ask your pupils if it is more important to have reliable knowledge of the strength of a suspension bridge cable or of a fishing line. If a playground supervisor were organizing basketball teams, in which case would he want to know more about each player's ability: when the teams were for a season's league, or when they were for just one afternoon? In choosing one-afternoon teams he might give each boy a chance to try one foul shot to show his skill. More trials, of different kinds, would

(Continued on the back page)

Dr. Nancy Kent Ziebur is a geneticist who has served as a substitute science teacher in Binghamton, N.Y. She is currently doing research at the University of Wisconsin, in Madison. Dr. Ziebur supplied most of the suggestions on page 2T for classroom use of "A Matter of Chance."



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(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **A Matter of Chance**
Penny-flipping experiments will give your pupils an idea of how chance operates and how past events can be used to figure the probability of similar events occurring in the future.

How It Works—Bathroom Scale

● **Travels of Your Thanksgiving Turkey**
Where the domestic turkey came from and some conjectures about how it got its name.

● **How Is a Flower Like an Elk?**
This WALL CHART shows examples of how the evolution of animals and plants is guided by the process of natural selection.

When Men First Learned To Farm
How archeologists have tracked down the beginnings of farming, and how farming changed people's lives.

Luring Backyard Birds
Homemade feeders will help your pupils observe the behavior of birds.

● **Be a Fingerprint Detective**
Your pupils will find out how to detect and identify fingerprints and learn another use of the fingertip ridges that make them.

IN THE NEXT ISSUE

Scientists living on a glacier probe deep into the ice to measure its pressures and motions and search for clues to past climates and inner-earth phenomena . . . What happened when men began to raise animals . . . How the English sparrow has changed in the U.S.A.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

A Matter of Chance

The penny-flipping experiments suggested in this article will give your pupils an idea of how chance operates, and how a sample of past events can be used to figure the likelihood, or probability, of similar events occurring in the future. By collecting and analyzing data, each pupil can find out that in a situation where chance is important, more information typically leads to more reliable conclusions. This concept will be reinforced if the data gathered by all of the pupils are pooled and analyzed.

Most of the following suggestions have been supplied by the author of "A Matter of Chance." Her article beginning on page 1T suggests ways to help your pupils relate probability to the problems of planning scientific experiments. (Another article on probability by Dr. Ziebur will appear in an early issue of *N&S*.)

Suggestions for Classroom Use

Your pupils probably won't need much encouragement to get into this article and begin flipping pennies; it's fun. But if the table and graph in the article should appear forbidding to some, you might get them started by having them read at least the first few paragraphs and compare their results from the first experiment.

I Total number of flips	II Number of heads	III Number of tails	IV Difference between heads and tails	V Fraction of heads
240*	0	240	240	0/240
480†				/480
720				/720
960				/960
1200				/1200
1440				/1440
1680				/1680
1920				/1920
2160				/2160

*30 X 8 PRETEND FLIPS
†30 X 8 REAL FLIPS

TABLE 1 (above) shows how to combine coin-flipping data from 30 pupils in a table that may show more clearly how the difference between heads and tails can vary while the fraction of heads to total flips tends to approach ½ in a long series of flips. (For graphing, the fractions in column V might be changed to percentages.) The same phenomenon can also be shown in a table of completely pretend flips, as in TABLE 2 (below).

I Total number of * flips	II Number of heads	III Number of tails	IV Difference between heads and tails	V Fraction of heads
10	4	6	2	4/10
100	48	52	4	48/100
1000	495	505	10	495/1000
10,000	4985	5015	30	4985/10,000

*ALL PRETEND FLIPS

The only equipment needed is pennies, pencils, and paper. (The pennies will roll less if flipped on a piece of cloth.) Some of your pupils will work faster than others on the main experiment. You might have the slower ones finish at home or encourage the faster ones to do another run of flips.

When all are finished, have them compare findings. How many found that heads "caught up" to tails (shown by a zero or an encircled number in column IV) at any time in the run? How many found that the difference between heads and tails got as high as 16 at any place in column IV? There will probably be a substantial number of pupils in each group.

The failure of heads and tails generally to even out will probably be shown also by the average of the last figures in everyone's column IVs (encircled numbers should be considered negative). The average difference is likely to be nearer to 8—just where it started—than to zero. Point out that each flip is a fresh trial that does not depend in any way on what happened in the flip or flips made before.

In graphing the results of their experiments, those pupils who see immediately how to plot their points might help those who have difficulty or are worried by the formidable-looking fractions toward the right end of the graph. Have your pupils compare their finished graphs. It should be evident that as more flips are made the fraction of heads divided by total flips tends to get closer to ½.

By pooling the results of the individual experiments in a single table *(see Table 1)*, you can show even more clearly how the difference between heads and tails can get wider and wider while the fraction of heads to total flips gets closer and closer to ½. This can also be shown in a table of all-pretend flips *(Table 2)*.

Activities

- There is about one chance in two of flipping a coin so that it comes up heads, or tossing a die so that an even number comes up (probability: ½). Can your pupils figure out the prob-

(Continued on page 3T)

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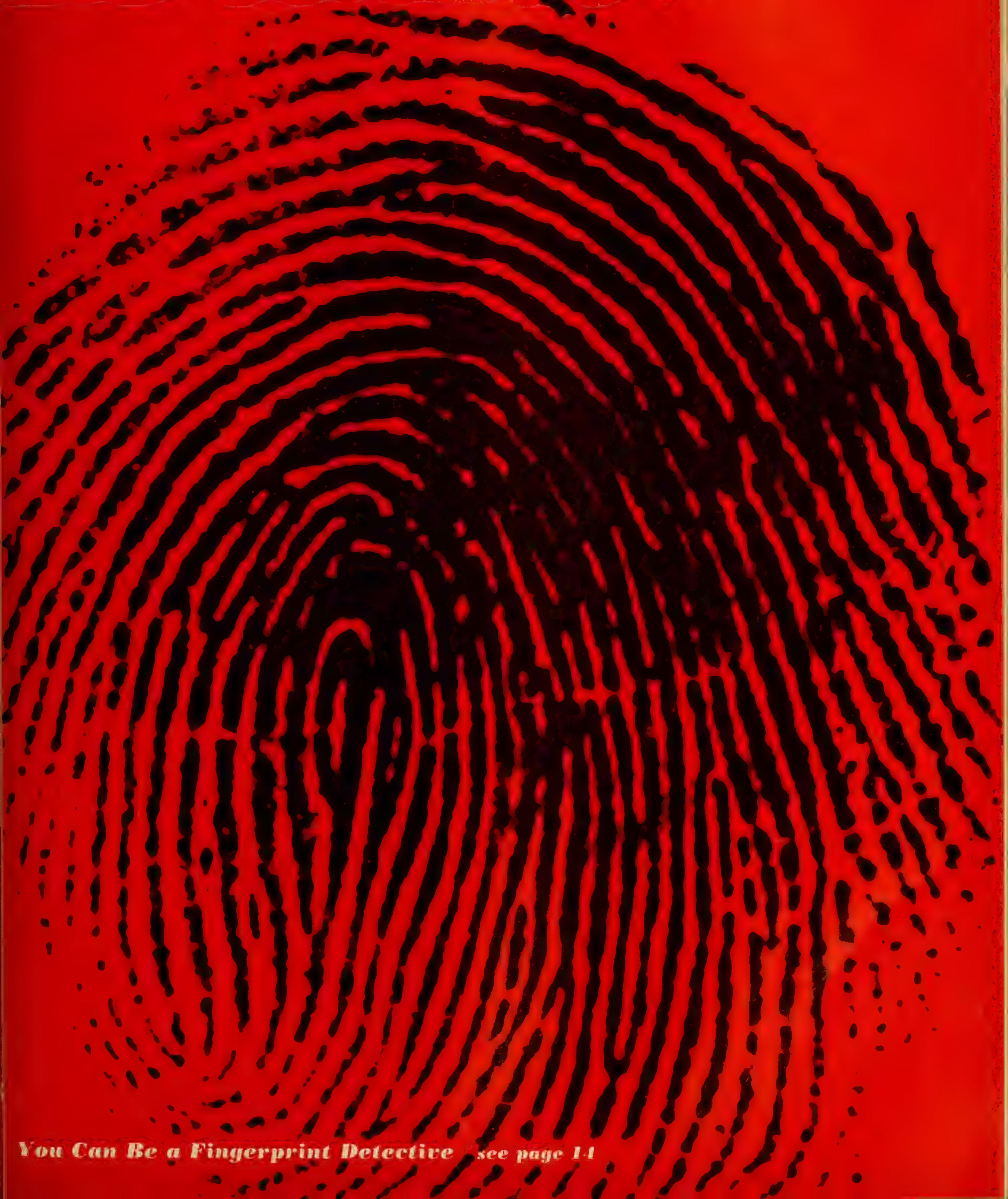
see page 8



You Can Be a Fingerprint Detective *see page 14*

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HEADS YOU READ THIS ARTICLE--TAILS YOU DON'T!

a ma

■ Have you ever tried to stand a penny on its edge
out having it lean against anything? Sometime whe
are in a patient and lazy mood, you might see if yo
do it. Work on a smooth, level surface. Try a few dif
pennies. Some pennies have worn, rounded edge
make the job almost impossible.

Even though you know that a penny can stand on
you wouldn't expect a flipped penny to land that
at least not very often. But what about heads and
When you agree to flip a coin to get help in mak
choice, there is usually no argument about who gets
and who gets tails. Most of us are happy with eithe
because experience has taught us that heads is just
as likely to turn up as tails—if the toss is a fair or

Exactly what do we mean when we say that a coi
likely to land head up as tail up? Does this mean
a coin is flipped twice, there will be one head an
tail? Try it and see. For a fair flip, make sure th
penny turns over in the air several times before la
Or, even better, shake it in a cup before dumping
Flip or shake the penny twice. Do several more pa
flips. Are there always one head and one tail?

Do the same sort of experiment by flipping a
four times instead of twice. Do you always get two
and two tails?

Although experience has taught you that the cha
getting a head is about the same as the chance of g
a tail, your experiment has probably shown that the

OKAY- LET'S FLIP
WHOOPS!! HOW DID THAT HAPPEN?

er OF CHance

by Nancy Kent Ziebur

· of heads and the *number* of tails in a series of flips en are not equal. Whenever you flip a coin many, many ıes, the *fraction* you get when you divide the number heads (or tails) by the total number of flips will be very ır to ½, that is, heads turns up about one-half the time. Some people believe that because this is true, it is also e that if you get many tails in a row, somehow there is reater chance that the next flip will turn up a head, "to n things out." This is not true. What has happened ·ing past flips has nothing to do with what will happen he next flip or flips.

You can do an experiment that will help you understand se two interesting facts about coin flipping:

:. If a coin is flipped many times, the actual *numbers* ıeads and tails are no more likely to "even out" than y are to become farther apart.

:. If a coin is flipped many times, the *fraction* of the ıl flips that are heads (and the fraction that are tails) is y likely to "even out" to about ½ of the total number lips. This is what is meant when we say that a coin is as ly to land head up as tail up, or when we say that a ı will land head up about half the time.

ing To "Even Things Out"

'o see whether many flips will "even things out," start ı the first few flips giving lopsided results. To do this, ply pretend that you have flipped a coin eight times and : it has landed tail up each time. Then *really* flip a coin 64 times, and keep track of your score as you go along. You can use the chart below.

Flip a coin eight times, and add the results to the heads and tails already marked on the chart (columns II and III). For example, if your first eight throws after the pretend group come out five heads and three tails, write 5 in the heads column (0+5) and 11 in the tails column (8+3). Keep recording the results of groups of eight flips. Figure

(Continued on the next page)

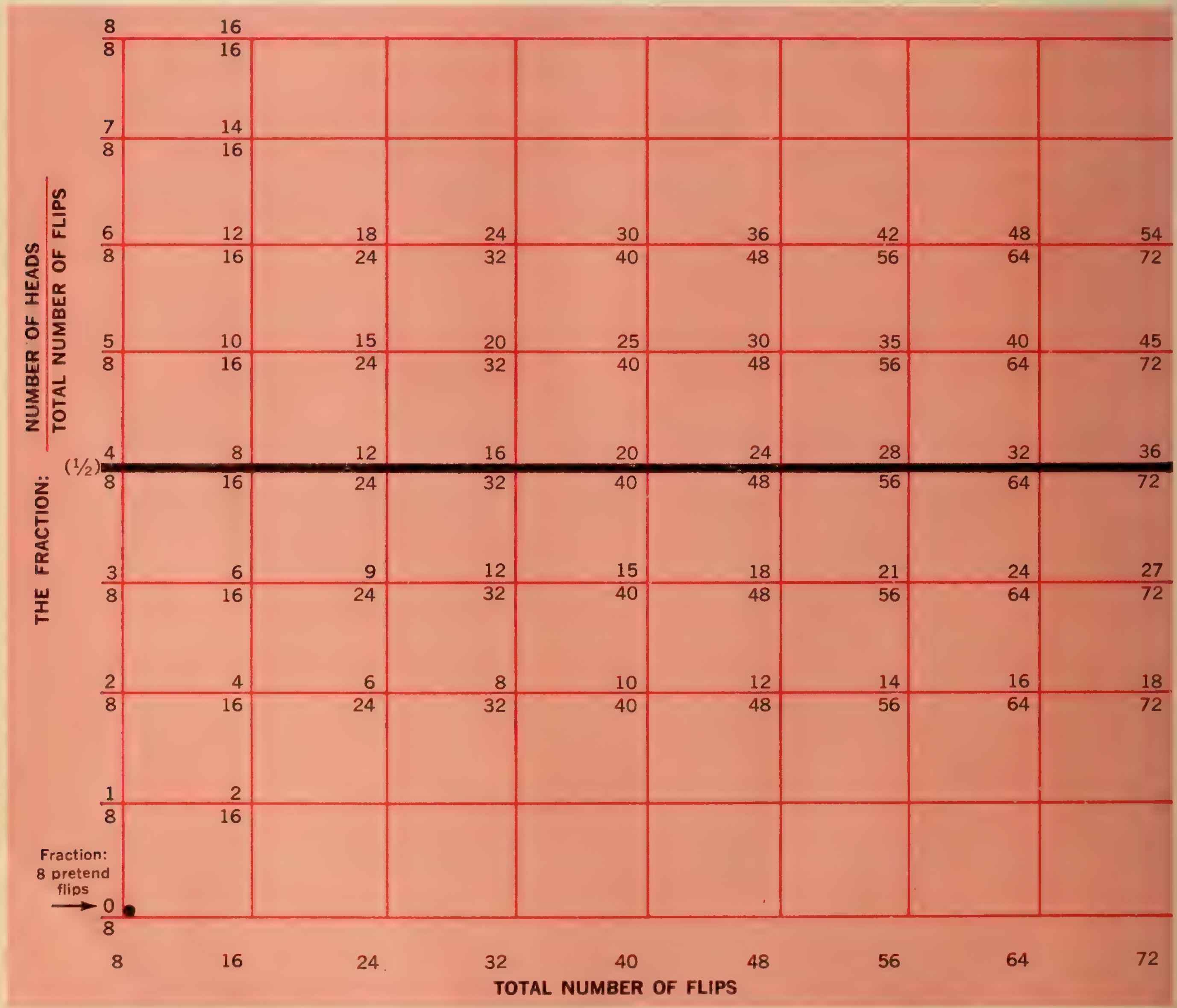
	I Total number of flips	II Number of heads	III Number of tails	IV Difference between heads and tails	V Fraction of heads
pretend flips	8	0	8	8	0/8
+8 real flips	16				
	24				
	32				
	40				
	48				
	56				
	64				
	72				

out column IV as you go along. Each figure in column IV shows the difference between the number of heads and the number of tails. If there are ever more heads than tails, put a circle around the number in column IV. Column V will be explained later.

After your chart is full you will be able to answer the first question: Do the *numbers* of heads and tails (the numbers in columns II and III) tend to become equal as you flip many times? If a number in column IV is 0, you will know that at that point there were the same number of heads as tails. If column IV changes over to a number with a circle around it, you will know that the number of heads has caught up with and passed the number of tails.

If you were to repeat the whole experiment many times, you would probably find that the heads would catch up with the tails in less than half of the experiments. (Also, in less than half of the experiments there would appear differences as large as 16!)

With a little more figuring you will be able to answer the second question: Does the *fraction* of heads tend to become ½—that is, 50 per cent heads and 50 per cent tails? You will have to find out what fractions of heads there were at various stages in the experiment. Write the fractions in column V. For instance, after the eight pre-



If you need to make a mark at 6/16 (6 heads out of 16 flips) you will find that the graph shows you the place. If you must make a mark at 5/16, you will have to put it halfway between 4/16 and 6/16. As the denominators get larger you will not be able to guess the position quite so accurately. After your scores are all marked, draw lines connecting each point with the one after it. Can you see how the fraction of heads gets closer to ½?

PUTTING PROBABILITY TO WORK

If you were to make a long list of the different kinds of work that people do, many of the jobs would be ones that have something to do with *probability*—how likely it is that something will happen, or will not happen. In 12 cities across the U.S. the weather bureau uses probability in its rain forecasts. For example, the report may say that there is only a 25 per cent likelihood that it will rain today. This means that if weather conditions were about the same as they are today on a total of 100 days, we could expect it to rain on 25 of those days. (Expressed as a fraction, the probability of rain would be ¼.)

Insurance companies have specialists who figure out how likely it is for an automobile driver 17 years old, or 60 years old, for example, to have an accident. With such information the insurance company then decides on the cost of automobile insurance.

A manufacturer of hardware has an inspector who checks to see if the rivet making machine is working properly. The inspector cannot take the time to look at each rivet. If he inspects every tenth rivet will that be enough? Perhaps looking at one rivet in a hundred will be a good enough check. A probability specialist will help design the inspection system.

tend flips there were 0 heads in a total of eight flips. The fraction is 0/8. After the next eight flips there were perhaps five heads in a total of 16 flips. The fraction then would be 5/16. Take the numerator from column II and the denominator from column I.

Graphing Your Flips

Make a graph of these fractions. Then you will be able to see at a glance what sort of change has taken place. To get you started, here is an incomplete graph with the result of the first eight (pretend) flips on it (black dot). To help you mark the rest of your scores, some of the possible fractions are shown right on the graph.

You may feel that starting with eight pretend flips of all tails is not the same as starting with an "honest" run of eight flips. If you wish, you can start the experiment with a really lopsided start. Flip a coin many times, watching for a series of six, seven, or eight tails (or heads) in a row. Then, when you get that particular group, count it as the start of your first group of eight flips. Or, if you wish, start out with the results of the first eight flips you make.

The information you get from a long series of coin tossing is more reliable than that from a short series. In other words, 100 flips will tell you more about coin tossing than will only two flips. Two flips will often produce two heads; a series of eight can result in all heads, although this is not likely to happen. The likelihood of 100 fair flips turning up all heads is almost too small to imagine, although this *could* happen too.

Several experiments also give more information than just one of the same size. You may wish to repeat the experiments so that you can compare several graphs. You can speed up your work by flipping eight pennies at once, instead of flipping one penny eight times. The use of graph paper will also be helpful. It will be interesting to see the results of a friend's flips, or the results of many of your classmates' work. How do most of the experiments turn out? ■

INVESTIGATIONS

If you make new tables and graphs like the ones on the two preceding pages, you will be able to carry out these investigations:

1. Instead of flipping a coin, find a pair of dice, but roll only one (called a "die"). What you want to do is find out the probability of an odd or an even number landing face-up when you roll the die. Start with pretend rolls of eight odd (or eight even) numbers, then roll the die just as many times as you flipped the coin, and fill in the table, then the graph. Do you think that odd and even numbers are rolled about equally often?

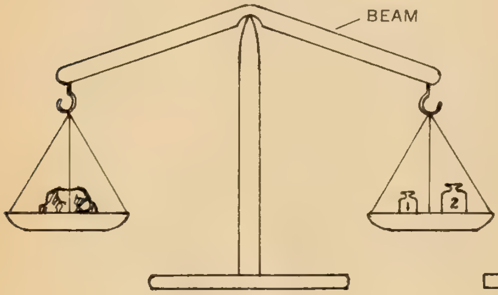
2. Repeat the experiment, using a die again, but choose one number on the die (say, 3) to be called a "success." When any other number is rolled, call that roll a "failure." Column I in the chart would be labeled "Total Number of Rolls," Column II, "Number of Successes," and Column III, "Number of Failures." Start with pretend throws of six successes and two failures. You will not find Column IV helpful, so omit it. About what fraction of your rolls are successes?

3. Repeat the experiment, using a jack instead of a die. Mark two of the round tips with a felt marking pen or small pieces of sticky tape. If the jack lands with both marked tips pointing upward, call that throw a "success." Call any other result a "failure." Start with pretend throws of six successes and two failures. Omit Column IV again. About what fraction of your throws are successes?

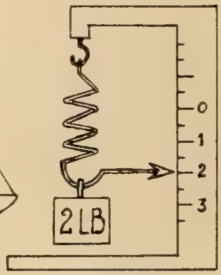
HOW IT WORKS

Bathroom Scale

■ A scale measures the weight of something by comparing it to things whose weight we already know. One way to do this is with a *balance scale*. This is a small seesaw with a pan hanging from each end *(see diagram).*



BALANCE SCALE



SPRING SCALE

When the thing to be weighed—say a stone—is placed in one pan, it pulls the *beam* down on that side and up on the other side. Things whose weight you know can then be placed in the other pan until the two pans are brought to the same level. Adding the weights of these things gives you the weight of the stone. (Chemists and druggists often use balance scales, because they measure weight so accurately. But imagine how hard it would be to weigh yourself on a balance scale!)

Another way to weigh something is to hang it from a spring. The heavier the weight the more the spring will stretch. First you *calibrate* the scale by hanging objects of different weight—say 1 pound, 2 pounds, and so on—from the spring and marking how far the end of the spring is stretched by each weight *(see diagram).* If you hung a large stone from the spring and found that it pulled the end of the spring to a point half way between 1 and 2 on the scale, you would know the stone weighed 1½ pounds.

Hanging from a Spring in Your Bathroom

You may be surprised to find out that when you stand on the *platform* of a bathroom scale, you are hanging from a spring *(see diagram 1).* Your weight pushes down the platform, which in turn pushes down on two triangle-shaped plates. These plates are *levers,* supported on *fulcrums,* or posts, at two corners. The unsupported corner of each of these levers pushes down on a third triangular lever whose moving corner is hooked to the end of the spring. These levers bring weight from all parts of the platform to bear on the spring, so it doesn't matter where you stand on the platform.

As the spring stretches, a V-shaped piece of metal attached to the end of the spring turns and pulls the *rack* toward the spring *(see diagram 2).* The rack has teeth something like those on a saw blade. When the rack moves, it turns a long, thin gear, called a *pinion,* at the other end of the scale. A pointer attached to the pinion turns with it, showing how much the spring has stretched, and pointing to your weight on the scale's dial. —Richard M. Koff

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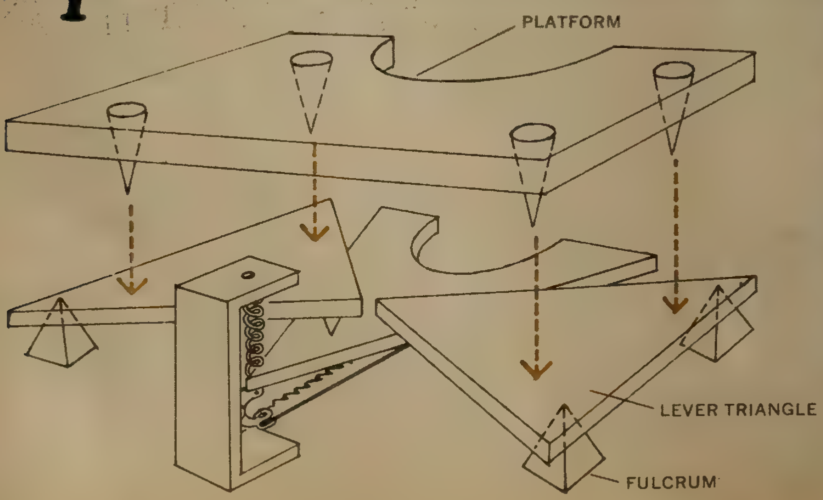

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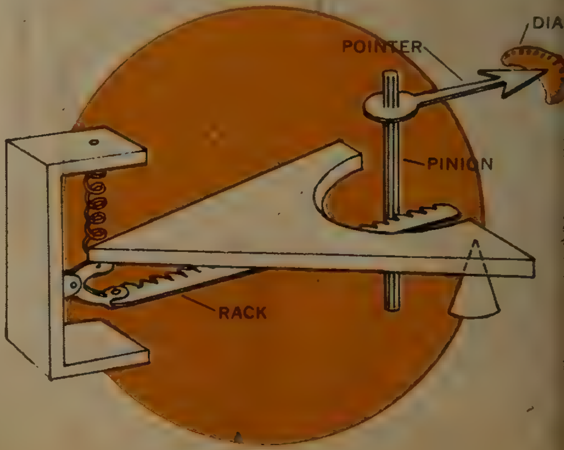


TRAVELS OF YOUR THANKSGIVING TURKEY

The ancestors of these Thanksgiving turkeys lived centuries ago in Mexico, where the Aztecs first tamed wild turkeys.

■ "Hmm. Very good."

"Please pass the gravy."

Probably your family will celebrate this Thanksgiving with a turkey dinner. Wait for a lull in the conversation. Then casually say, "How do you suppose the turkey got its name?" Or "Funny thing, the way turkeys came to us by way of Mexico and Spain, isn't it?"

Now you have everyone's attention. Tell them this story.

When the Spaniards conquered Mexico early in the 16th century, they found that the Aztecs were raising flocks of big birds—one of six races of wild turkeys that lived in North America at that time. Except for one other kind of turkey in Central America, turkeys lived nowhere else in the world.

Cortez, the leader of the conquering forces, took some turkeys back to Spain with him. By about 1530, turkeys were being raised throughout Europe.

When the Pilgrims had their historic first Thanksgiving, they had no tame turkeys and feasted on wild turkeys from the forests. But before long, other settlers from Europe brought domesticated turkeys to North America. So the turkey was brought *back* to its ancestral home—120 or so years after leaving Mexico for Spain.

According to the reports of the early settlers, the wild turkeys were bigger than the turkeys brought from Europe. The tame turkeys, like their Mexican ancestors, were still smaller than the race of wild turkeys that lived (and still lives) in eastern North America.

Since those times, however, scientists have learned how to develop breeds of animals with special characteristics (such as chickens that lay many eggs) by mating carefully selected parent animals. In this way, several breeds of turkeys have been developed, all bigger and meatier than their wild ancestors. Now each year about 100 million turkeys are raised in the United States alone.

How Did The Turkey Get Its Name?

According to one story, when Cortez first brought turkeys to Spain, people confused them with the guinea-fowl, a chicken-sized barnyard bird that was brought from Turkey at about the same time. For a while both birds were called "turkey" and, so the story goes, the name stuck to the birds we call turkeys today.

Some people claim that the word "turkey" began with an Indian name for these birds—"furkee." On the other hand, others say that the Indians learned the name "turkey" from the European settlers, then mispronounced it as "furkee."

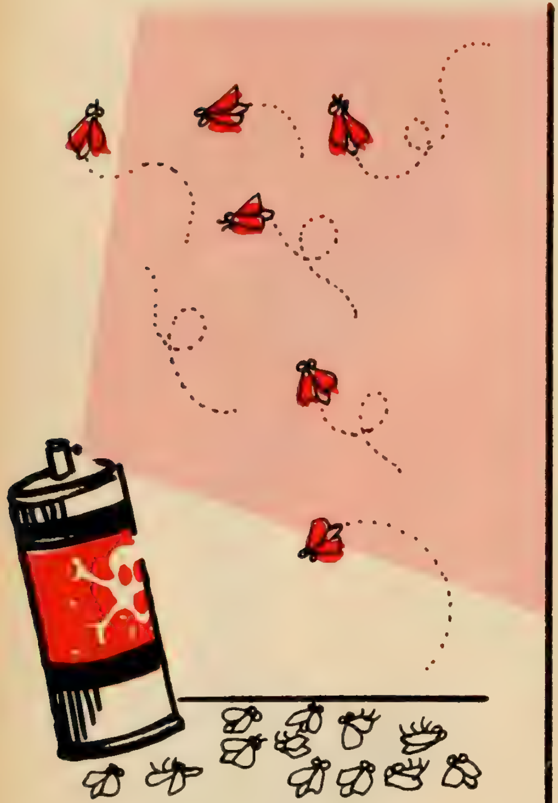
One early naturalist said that the turkey got its name from its call note, which he translated as "turk, turk." Since then, however, many naturalists have pointed out that the turkey's call note sounds much more like "keow, keow" than "turk, turk."

Just how the turkey got its name is a mystery that may never be solved. It is something to puzzle over as you bite into a drumstick this Thanksgiving ■

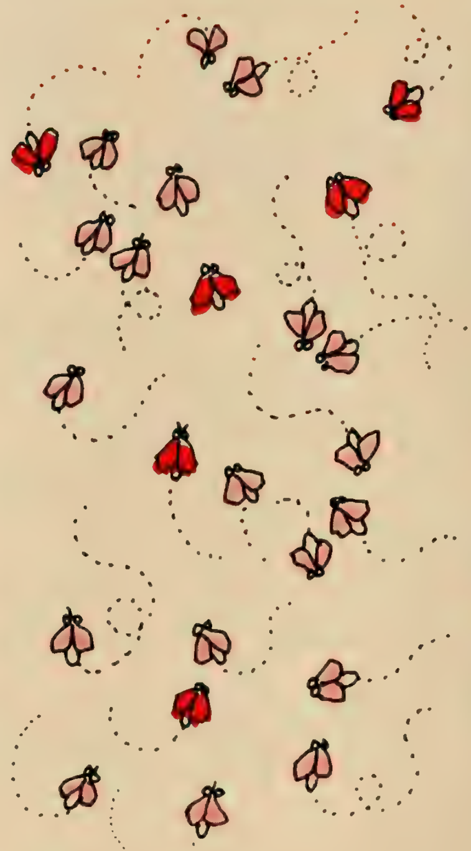
PROJECT

Wild turkeys were wiped out in many parts of the country—mostly by destruction of the forests they need for food and cover. Now, however, many states have good-sized populations of wild turkeys and game biologists are working to bring wild turkeys back in other areas. Look in books about birds to find out if wild turkeys are living, or once lived, in your area. Write to your state conservation or fish and game department (in the state capital) to get more information about wild turkeys in your state.

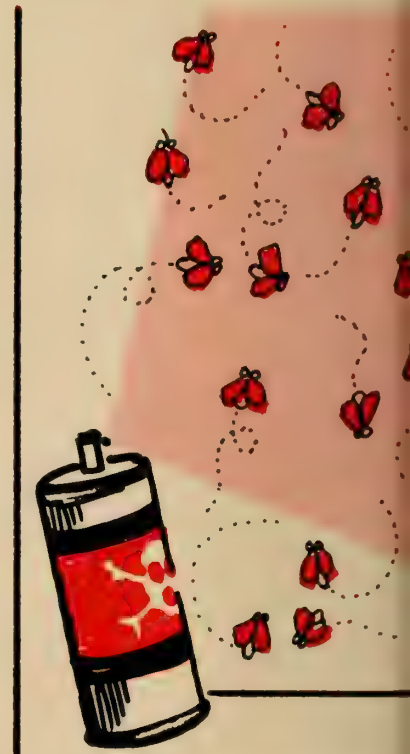
How Is a Flo



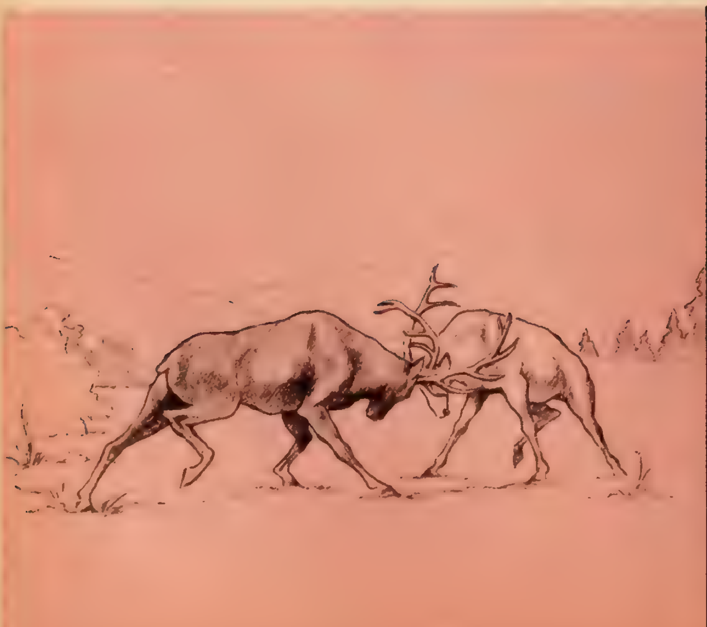
When the insect spray DDT was first used on houseflies in a particular area, most of the flies were killed. But a few (shown in color) survived. These flies had the ability to resist DDT.



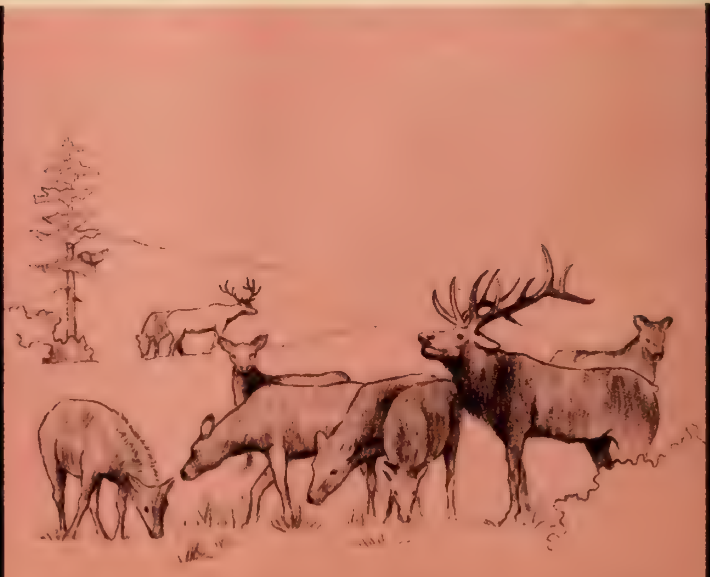
The few flies (dark color) that were not killed by the DDT lived to produce offspring (light color) which also were able to resist DDT.



After DDT had been used fo
years, flies in the area were
killed by it. All the flies that
resist DDT had been killed off
flies with the resistance had li
produce. A new population o
sistant flies had evolved.



Bull elk compete with each other for cow elk.



Each bull tries to collect a harem and the bull mates with the cows of his harem. The more dominant, or "bossy," bull will have a larger harem.

er Like an Elk?

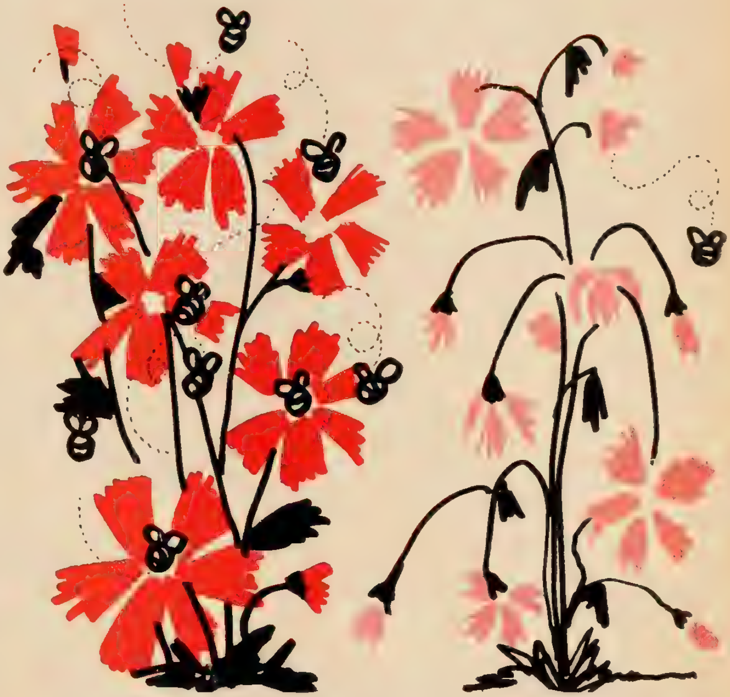
■ About one hundred years ago Charles Darwin and Alfred Wallace proposed the theory of *natural selection.* Darwin had studied and raised domestic animals for many years. He knew that no two animals were exactly alike, even animals with the same parents. He also knew that animals could pass on their different characteristics to their offspring. A strain of animals with a certain characteristic—such as sheep with especially thick wool—could be developed by breeding only animals that had that characteristic.

Darwin and Wallace suggested that changes in the characteristics of all plants and animals are guided by natural selection. For natural selection to work, an animal or plant must live long enough to be an adult and must be able to reproduce. Reproduction is the key to natural selection. An animal or plant must reproduce so that a characteristic can be passed on to the next generation.

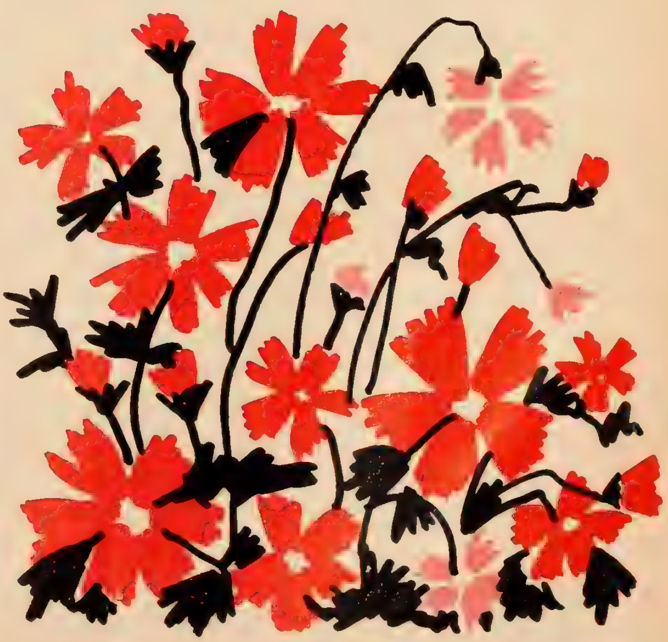
Anything that increases the chances of reproduction also increases the chances that a characteristic —such as bright color in flowers—will be passed on to the next generation. The same is true of any trait that increases the numbers of sex cells, and the number of young (*see flower diagrams*).

The change in the characteristics of a group of plants or animals through time is what we call *evolution.* Usually this is a very slow process taking millions of years, and can only be studied by observing the differences in fossil plants and animals. Sometimes, however, it happens in a short time and we can actually see the results. The illustrations on this WALL CHART show some ways in which natural selection works to guide evolution. The theory of natural selection helps explain the fact of evolution.

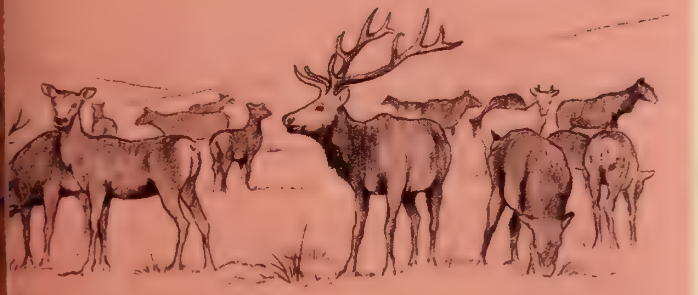
— MARGARET R. BULLITT



Most flowers are cross-pollinated by insects, which carry the pollen from one flower to another. The flowers must be fertilized by pollen from the same kind of plant. The bright flowers shown here are more attractive to the insects than the pale-colored flowers. The bright flowers are also all blooming at the same time, so many more of them have ripe sex cells available for pollination than do the pale-colored flowers.



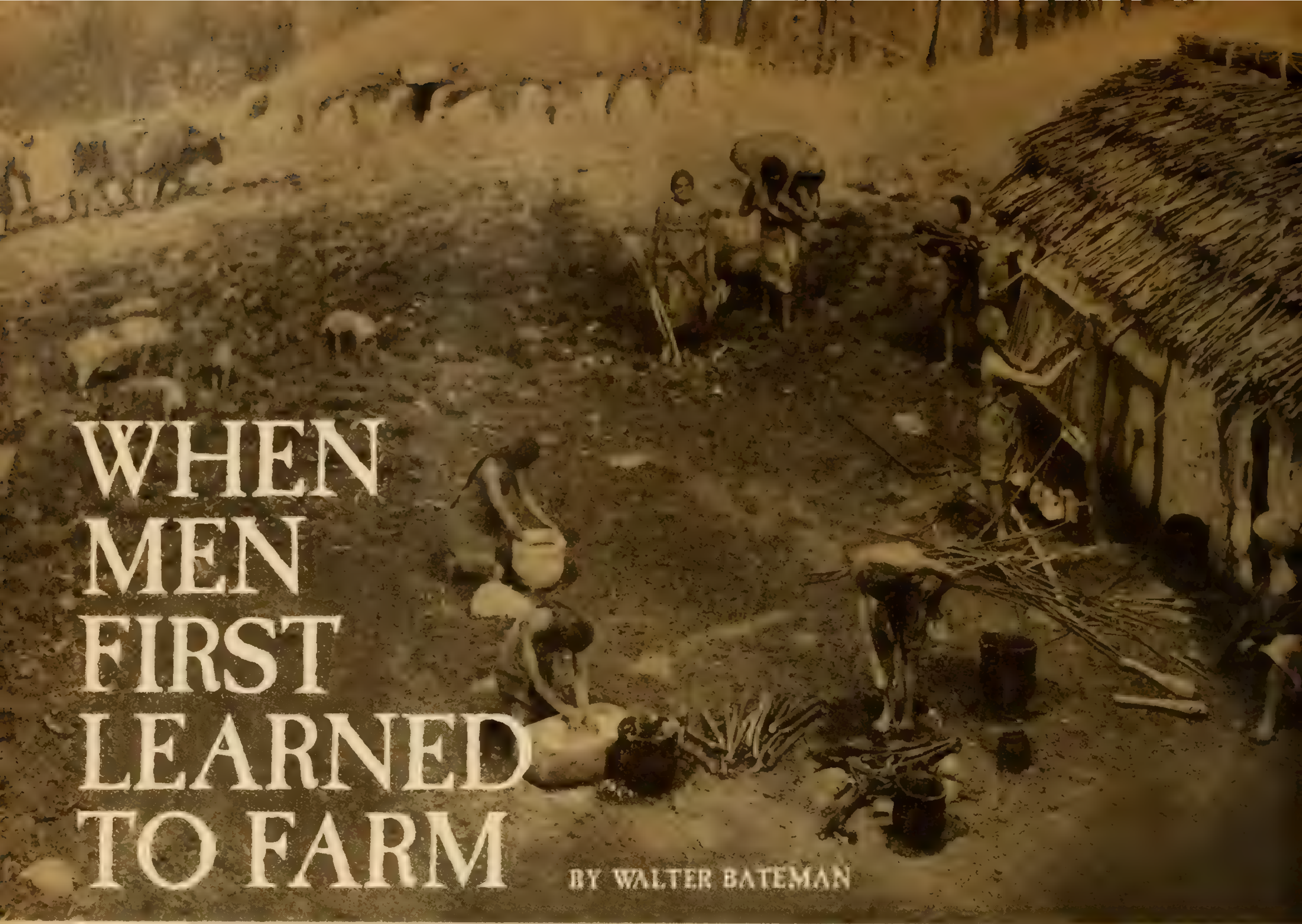
Since there were more sex cells of the bright-flowered plants and a bigger portion of them were fertilized, the bright-flowered plants will have more offspring than the pale-flowered plants.



tion will have more elk with the characteristics of the bull. These elk in turn will pass on these characteristics d the generations that follow.

WHEN MEN FIRST LEARNED TO FARM

BY WALTER BATEMAN



This scene showing farmers at work about 2700 B.C. in what is now Denmark was made up from the findings of archeologists. When men began to farm, about 5,000 years earlier, they loosened the soil with hoes and picks, not plows.

About 10,000 years ago, some people learned to raise plants for food. This is the story of how their tools and seeds have been found and how farming changed the lives of these ancient people and all who lived after them.

■ High on a dusty hill in northern Iraq a team of archeologists were digging up an old village called Jarmo *(see map on next page)*. They staked out the land into squares, then dug up the dirt and sifted it through screens, looking for pottery and stone tools. They found the remains of an older village where farmers had lived thousands of years ago. Underneath those house floors they found the remains of still older ones. Altogether, they found at least a dozen layers of house floors.

In the bottom, or oldest, layer the diggers found some clues as to how these ancient farmers had begun to farm. They found stone tools and the bones of sheep and goats and some fossils of wheat. Dr. Robert Braidwood, a Professor of Anthropology at the University of Chicago, was in charge of the digging. He said that one fossil of wheat was most unusual. It was not a kernel of wheat that had turned to stone. Instead it was the impression left by a wheat kernel that had been pressed into clay. The clay had hardened with that wheat-print still in it. Such ancient wheat had kept its silent message for nine thousand years until the archeologists discovered it.

The wheat's message seemed to be: "We men of Jarmo were not hunters only. We also gathered the seeds of wild grasses. We ground them into flour for food. Look at our village."

The digging at Jarmo began in 1948 and has continued there and at other villages in Iran and elsewhere in the Middle East. The diggers look at such villages very carefully. They search for clues that will help them figure out

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when men began to plant seeds. In the dusty ruins of old mud-walled villages in Palestine, Turkey, Iraq, and Iran, they have found a lot of evidence. (On the map you can see this region marked as the Fertile Crescent.)

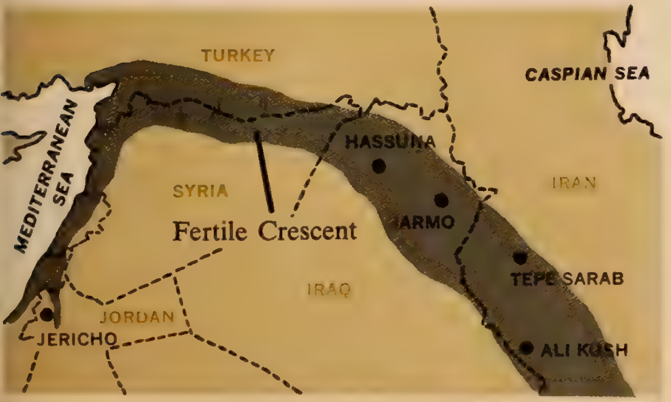
Tools for Cutting, Tools for Planting

At Jarmo they found *querns,* flat stones used for grinding seeds. So we know men there ate ground-up seeds. The archeologists also found sickles—sharp blades of flint set in handles of wood or bone—for cutting the grain. Dr. Braidwood thinks that men may have used sickles and querns on wild grain for many hundreds of years before they learned how to plant the seeds. But when the diggers also found the garden tools—the hoes and the picks needed to loosen the soil—then they decided that these ancient men probably had also been planting the seeds. At the oldest levels the diggers found no hoes, but they did find heavy stones with holes drilled in them, which were probably used as weights near the pointed ends of digging sticks. The wooden sticks, of course, have rotted away.

In Jarmo and also in places like Jericho and Tepe Sarab and Hassuna *(see map),* the earliest grains are wheat and barley. They are simpler kinds of wheat and barley than we have today, and are something like the wild grains called emmer wheat and two-row barley. By *radioactive dating (see next page),* the scientists figured out that the seeds found at Jarmo had probably been planted there as long ago as 7000 B.C.

About a thousand years later, the Indians in what is now Mexico were learning to plant different crops. Archeologists have found evidence that squash and avocadoes were being planted there about 6000 B.C., followed by chili peppers and beans, and that by about 5000 B.C. the Indians had begun to plant corn.

This corn was a wild grass with an open husk that let the tiny kernels scatter, so that the plant reproduced itself long before men planted the kernels. But as this plant was cross-bred with other plants to produce larger cobs and kernels *(see next page),* its husk became stronger and tighter. Because of this, corn can no longer scatter its own kernels; it needs man to plant it.



Diggers are shown uncovering the remains of house built of mud bricks thousands of years ago at Ali Kosh, in Iran.

You can probably guess some of the ways that men's lives were changed when they began to grow their own food. Hunters who began to farm would want to live near their crops. As they farmed more they would build more permanent villages. They would have more food. Their population would grow. They would begin to specialize in their work. They would develop differences in wealth and in rank.

But we need more than guesses. We need the evidence dug by the archeologists. The evidence they found shows that these guesses are just about right. But the process took a long, long time.

Dr. Frank Hole, a Professor of Anthropology at Rice University, Houston, Texas, found a site at Ali Kosh, in Iran, that had been occupied from 8000 B.C. to 4000 B.C. *(see photo).* At the oldest level, about 8000 B.C., his team found a village of hunters and gatherers who did some simple farming. They planted emmer wheat and two-row barley and reaped it with sickles. They built houses out of mud bricks. Since all houses found were about the same size, Dr. Hole saw no sign of a chief or a wealthy man.

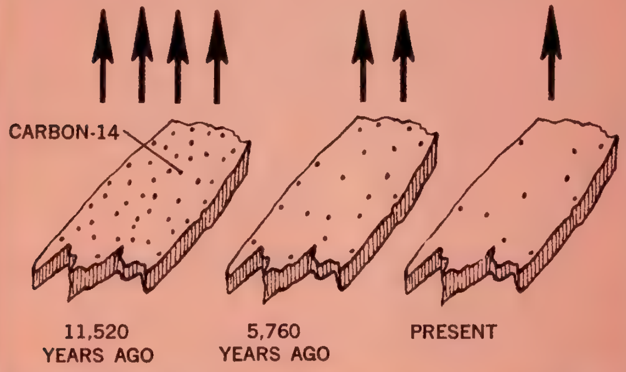
At the 6000 B.C. level weeds were more abundant. After two thousand years of planting and hoeing on the same site, the farmers had begun to ruin the soil. (It is worse now. Much of the Fertile Crescent, where farming began,

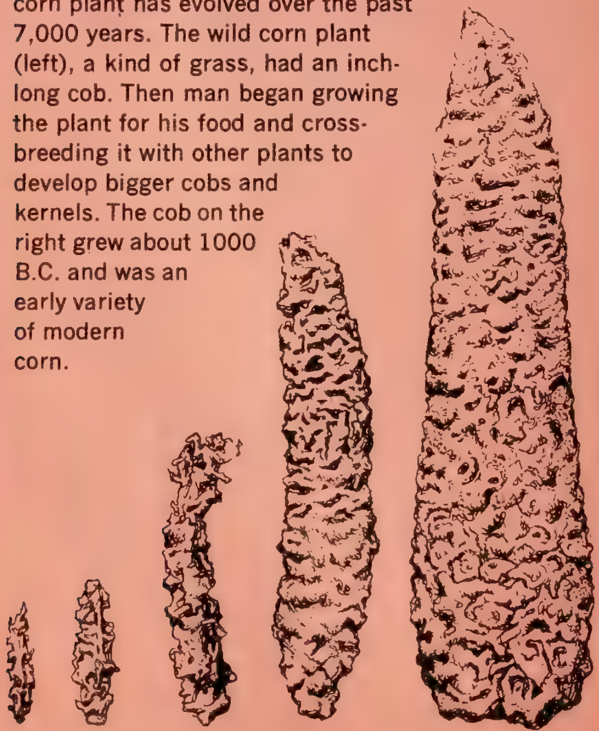
(Continued on the next page)

DATING FOSSILS BY RADIOACTIVITY

Living plants take in from the earth's atmosphere a rare type of carbon called *carbon-14*. Carbon-14 slowly but constantly changes into another element, nitrogen-14. As the carbon-14 in a living plant changes into nitrogen-14, it is replaced by more carbon-14 from the atmosphere. Animals also take in carbon-14 from the plants they eat.

When a plant or animal dies, it stops collecting carbon-14. The amount of carbon-14 in the remains of the plant or animal gets smaller as it changes to nitrogen-14. No matter how much carbon-14 a dead plant or animal may have, it takes 5,760 years for half of its carbon-14 to disappear. (This period of time is called the *half-life* of carbon-14.) It then takes another 5,760 years for half of the remaining carbon-14 to disappear, and so on (see *diagram*). By measuring how much carbon-14 is left in a piece of wood, for instance, scientists can figure out how long ago the wood was part of a living tree.





These drawings of fossil corn cobs show how the corn plant has evolved over the past 7,000 years. The wild corn plant (left), a kind of grass, had an inch-long cob. Then man began growing the plant for his food and cross-breeding it with other plants to develop bigger cobs and kernels. The cob on the right grew about 1000 B.C. and was an early variety of modern corn.

When Men First Learned To Farm (continued)

has been turned into desert, partly from bad farming practices.) They used stone hoes and they had begun to make pottery. Sheep were also kept as well as goats. But the many bones of wild animals show that men still did a lot of hunting.

And at the 4000 B.C. level the farmers planted a better type of wheat and barley with more grains in each head. They dug simple canals for irrigating their gardens. The archeologists found bits of cloth and also round weights used on stick spindles for spinning thread. Weaving must have begun. The pottery was well made and so standardized that it probably was made by a specialist. The bones of cattle show that they were being raised instead of hunted.

Strangely enough Dr. Hole did not discover how the people stored grain. But in other places, such as El Faiyum, near the Nile River, grain was stored in straw baskets under the ground.

Statues and Temples

Because the farmers had more food, the population grew. A village might hold about 200 persons. The number of villages increased over the valley, showing that there were more people.

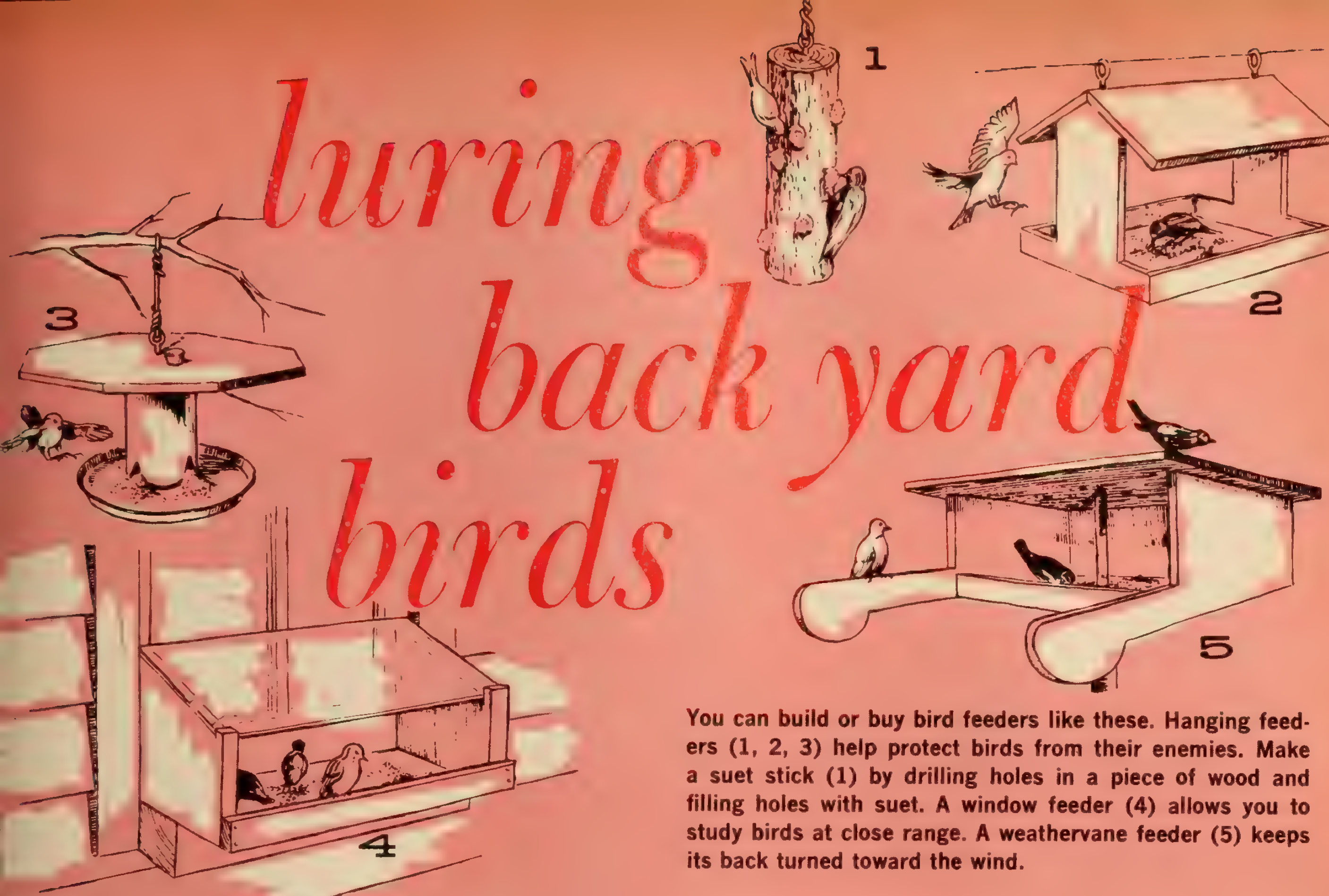
Among many of the dug-up ruins have been found curious little clay statues or stone statues. Some are of goats. Some are of women. Many of them seem to show a concern with reproduction, as if the farmers were using the statues as good magic. Perhaps they thought the statues would increase their goat herds or help to grow better crops or help to have more children.

In Mexico, also, thousands of little clay figures have been found. We don't know what beliefs were connected with them, but whatever they were, such beliefs seem to have grown more complex as time passed. And then, even as the potter became a specialist in making pots, so the priest became a specialist. The priest specialized in dealing with the spirit world, the world of beliefs.

Temples are the best sign of this specialization. Temples appear early in villages in the valley of the Tigris and Euphrates. Jericho had a temple. So did Eridu and Gawra. Wherever the skills of farming spread, having more food gave people more time for other things. They began to trade such things as food and cloth with other people, to write, to live together in larger groups under a leader, and to fight wars with other groups of people. But that is another story.

When man learned to control his food supply, he made the most important invention in all his long history. He was now ready for the big step from little mud-walled villages like Jarmo to cities and to civilization ■

luring back yard birds



You can build or buy bird feeders like these. Hanging feeders (1, 2, 3) help protect birds from their enemies. Make a suet stick (1) by drilling holes in a piece of wood and filling holes with suet. A window feeder (4) allows you to study birds at close range. A weathervane feeder (5) keeps its back turned toward the wind.

■ Do nuthatches eat nuts? Do blue jays like the color blue? You can try to answer these and other questions about the ways of birds this winter by feeding birds in your back yard.

Birds usually don't need to be fed to survive the winter. They do very well searching for such food as weed seeds and insect eggs, unless a blizzard or ice storm covers all of their natural food for several days. The best reason for feeding birds is to attract them so you can study them.

A feeder can be as simple or complex, as costly or as inexpensive as you want it to be. You can buy bird feeders from garden stores and pet shops or make them from scrap lumber and other household items. The diagrams on this page may give you an idea of the kind you would like, and the books listed below give detailed directions on how to build many kinds of feeders.

The kinds and numbers of birds that a feeder attracts depend on its location and the kinds of food offered. A feeder set in the middle of a lawn may not attract birds, because there is no nearby shelter for them. If you have no shrubs where birds can hide, drape or hang some pine boughs near the feeder for shelter.

To attract seed-eating birds, such as sparrows, cardinals, and juncos, offer seeds of sunflower, hemp, and millet, and grains such as corn and wheat. These are available from garden and seed stores. Insect-eating birds, such as woodpeckers and chickadees, are attracted by peanut butter, suet, and fat trimmings (from a meat market). You can experiment with other kinds of food, such as fruit and table scraps. Begin putting out food in the autumn. Then the birds will discover the feeder and will begin using it as soon as winter arrives.

Some Things To Watch For

Take notes on what kinds of birds visit the feeder. When and how often do they visit? How long does a single bird or flock of birds stay at one time? Note the weather and see how it affects bird feeding.

Try to discover where else the birds roam in your neighborhood. What is the size of their winter territory? Is it bigger or smaller than their summer territory? Why?

You can learn a lot about bird behavior at a feeder. Do the birds feed one at a time, or in groups? How close will a bird allow another bird to get to it? Do some kinds of birds chase others away from the food? Do birds eat at the feeder or carry food away? What do birds do while waiting to get to the feeder?

Color some sunflower seeds with food coloring. Then put equal numbers of the different colors and of normal seeds in the feeder. Do the birds avoid any particular color? If so, can you figure out why? ■

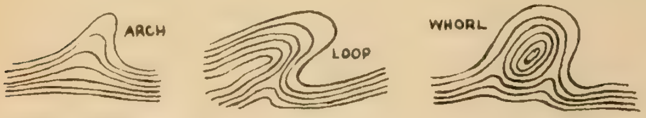
■ These books include plans for building a variety of bird feeders: **Songbirds in Your Garden,** by John K. Terres, Thomas Y. Crowell Co., New York, 1958, $4.95; **Field Book of Nature Activities and Conservation,** by William Hillcourt, G. P. Putnam's Sons, New York, 1961, $4.95.

With some talcum powder and Scotch tape, you can pick up fingerprints from a glass and find out who touched it.

How to be a Fingerprint Detective

by David Webster

■ Do you know what kind of fingerprints you have? There are three main types: loops, arches, and whorls *(see diagram)*. Look at your fingers and see if you can tell which you have on each finger. Are all your fingerprints the same type? Is your left hand the same as your right?

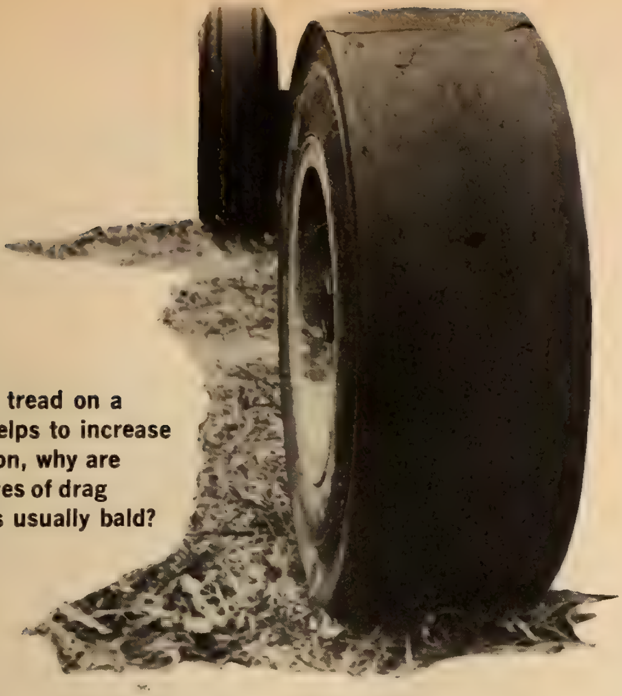


No two people have fingerprints that are exactly alike, but there are three main types of fingerprints.

You can see your fingerprints better by inking your fingers like a rubber stamp. Use the ink in a rubber stamp pad, or some fountain pen ink smeared on a piece of paper. (Detectives use a special kind of thick, black ink that is spread out with a roller on a piece of glass.) Roll your fingertip in the ink and then roll it over a piece of paper. With a little practice, you should be able to make clear fingerprints.

The skin on your fingers has hundreds of tiny ridges. If your finger is properly inked, these ridges become covered with ink and the spaces between them do not. When the inky finger is pushed on paper, the ink on the ridges leaves a pattern—the fingerprint. What happens to your fingerprints if you use too much ink?

The ridges on the palm side of your hand and fingers are known as *friction ridges*. They help you hold things by increasing *traction*, just as the tread on an automobile tire helps the tire grip the road. You can demonstrate this by laying your hand flat on a sheet of paper. With the palm of your hand against the paper, you should be able to



If the tread on a tire helps to increase traction, why are the tires of drag racers usually bald?

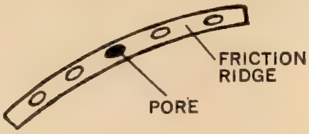
push the paper away easily. Can you move the paper with the back of your hand against it?

There are also friction ridges on the bottom of your feet. Unless you walk in bare feet, these ridges are of no value. The friction ridges of the feet are *vestiges.* Look up this word in a dictionary, and then see if you can explain why humans have friction ridges on their feet.

The Prints You Leave Behind You

Every time you touch something smooth with a finger, you leave a *latent,* or nearly invisible, fingerprint. Make some latent prints by holding a clean drinking glass between your fingers. Look at the glass in good light and you should be able to see some latent fingerprints.

You may wonder why a latent print is left when you touch something. If you could see one of your friction ridges through a microscope, you would see a number of tiny pits. These are *pores* that give off sweat and body oils *(see diagram).* The friction ridges are covered with a thin layer of oil that sticks to the glass when you touch it.



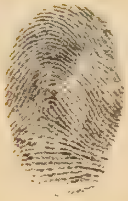
The pores on friction ridges give off sweat and body oils.

You can make a latent print easier to see by using powder. Talcum powder is best, but even corn starch or baking soda can be used. Shake a little powder on the glass you touched, and then blow the powder off. Some powder should stick to the oil left by the friction ridges. The white fingerprint will be easier to see if it is held against a dark background.

Detectives find fingerprints by dusting objects with special powders. They use a light powder if the latent prints are on a dark surface, and dark powder for prints on something light. The prints can be photographed and then removed with transparent tape for closer examination.

You can "lift" talcum powder prints with Scotch tape. Press a piece of tape on the print and then pull it off the glass. The fingerprint should be stuck to the tape. To protect the powder, stick another piece of tape on top of the print. You can study the fingerprint by taping it to a piece of dark paper ■

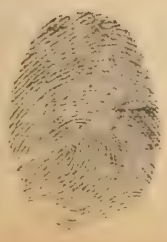
This print was made by a finger that was once badly cut. Can you see where the cut was?



For Fingerprint Experts Only

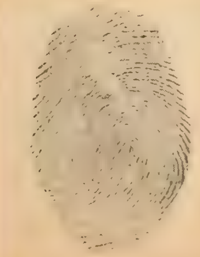
You can play detective by figuring out who in your family picked up a drinking glass. First, use ink to take the thumb print of your father, mother, brothers, and sisters. Then suppose that one of them leaves a thumb print on a glass while you are out of the room. When you come back, "lift" the prints with powder and tape. Whose thumb print matches?

WHO TOUCHED THE GLASS?

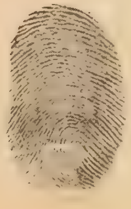


DAD

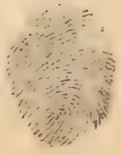
MOM



DOUG



JAY



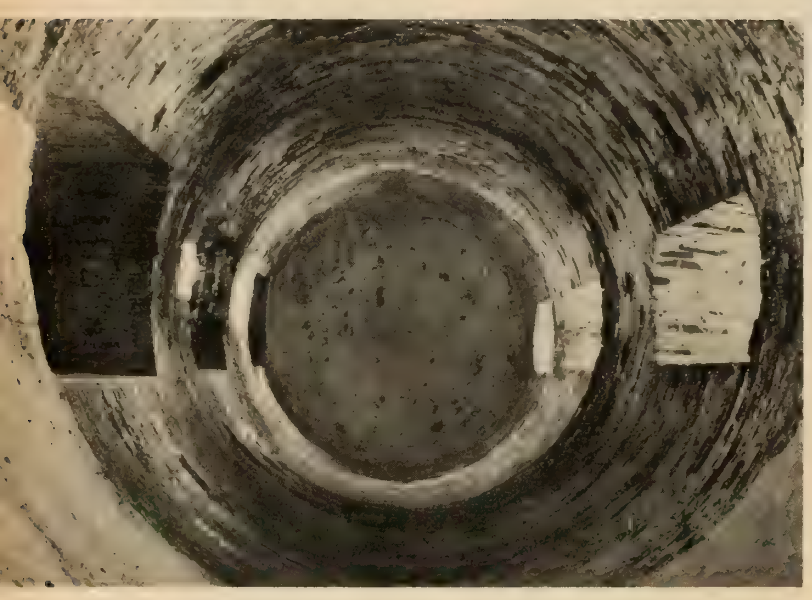
PRINT ON GLASS

BRAIN BOOSTERS

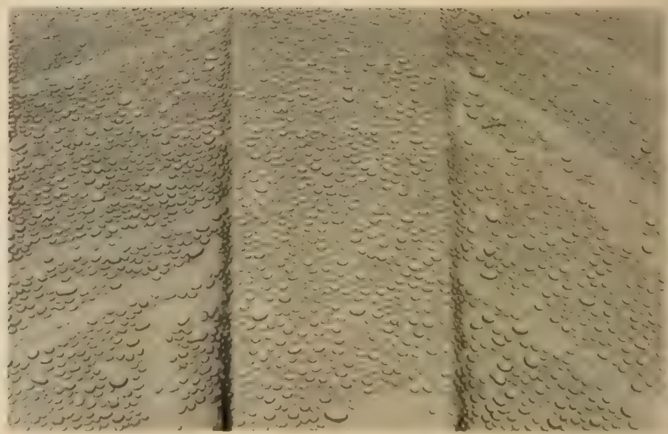
prepared by **DAVID WEBSTER**

Mystery Photos

What is this? Was the photograph taken looking up or looking down?



What is it?



Can you do it?

Can you find out, by looking at your water meter, how many gallons of water you use when you take a bath or shower? (Some meters measure cubic feet of water. 1 cubic foot equals 7½ gallons.)

Submitted by Bernard Oster, Lincoln, Massachusetts

Fun with numbers and shapes

If you were born in the year 4 B.C., in what year would you have celebrated your twelfth birthday?

Submitted by Bernard Oster, Lincoln, Massachusetts

For science experts only

1. What freezes as it melts?

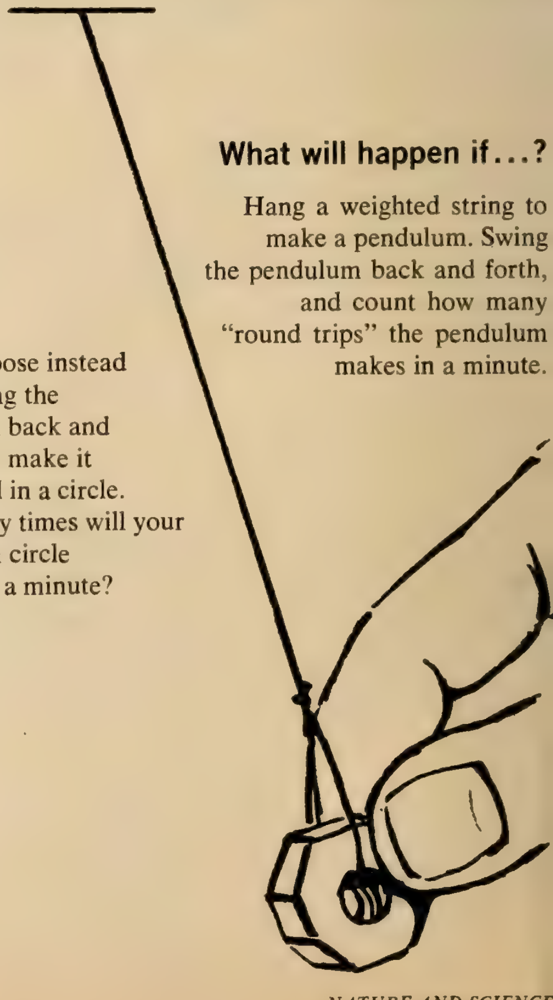
Submitted by Marcia Rhodes, Kingsley, Pennsylvania

2. How small can a mirror be in which you can see yourself from head to toe?

What will happen if...?

Hang a weighted string to make a pendulum. Swing the pendulum back and forth, and count how many "round trips" the pendulum makes in a minute.

Now suppose instead of swinging the pendulum back and forth, you make it go around in a circle. How many times will your pendulum circle around in a minute?



Using This Issue...
(continued from page 2T)

ability of a tossed die landing with, say, one dot up? (One in six, or 1/6.)

- You might have them try flipping a thumb tack (gently) to see whether it lands point up or down. The tack's irregular shape makes it unlikely that the tack will land point up in about half of the total flips. Graphing the results of a series of flips will probably show that the fraction of point-ups to total flips tends to level off, but probably not at a fraction of ½.

Topics for Class Discussion

A coin flip is a simple event whose outcome is determined essentially by chance. We must observe many of these events to reach a useful conclusion about how the flips are likely to turn out. Even when a happening is controlled only partly by chance, predictions about it must be based on more than a few observations.

- Have your pupils think of some questions that would require observation of a great many events in order to reach a useful conclusion. For example: Does fluoride help keep teeth from decaying? Do measles shots work? Can you study better with the TV turned on or off? Will a baby sleep better lying on its back or on its stomach? Which of two kinds of glue is stronger? If a black cat crosses your path, will you have "bad luck"?
- Ask your pupils how they might go about answering the black cat question. One way would be simply to ask: Does it seem reasonable for the color of a cat to have any effect on the life of a person whose path it crossed? Another way would be to make a survey of people whose paths had been crossed by a black cat and find out what happened to them. (The first way may seem good enough to some pupils, but you might remind them that history is full of "reasonable" conclusions—"the earth is flat," "the earth is the center of the universe," etc.—that have been disproved through scientific investigation.)

To make the black cat investigation and reach a useful conclusion, you would have to define "bad luck" in order to decide whether things that happened to people could be so labeled. You would also have to decide on a time limit on events that might be blamed on the cat, because sometime in his life everyone has what might be called "bad luck." And you would also have to decide how many people whose paths had been crossed by black cats you would have to investigate in order to reach a meaningful conclusion. (Some of the problems involved in deciding this last point are discussed in "Probability and Your Pupils" on page 1T.)

Have You and Your Pupils Seen These TV Science Programs?

- "Animal Secrets," a series of half-hour films about the mental, biological, and social activities of animals, on NBC network TV stations Saturdays at 1 P.M. (E.S.T.) through February 11. Schools can buy 16-mm film copies in black and white or color. Write to The Graphic Curriculum, Inc., 41 East 42 Street, New York, N.Y. 10017.
- "Experiment," a series of eight half-hour programs, appears on National Educational Television network stations (check your newspaper or local station for schedule). Using simple demonstrations, a scientist tells how he made an important discovery in the physical or life sciences. The program is conducted by Don Herbert, TV's "Mr. Wizard" for 14 years.

Turkey Travels

Thanksgiving time provides plenty of raw material for reconstructing a bird skeleton. You might have your pupils work in teams, each group putting together a turkey. This project can give them some ideas about the adaptations of birds' bodies (such as hollow bones that help make flight possible). Your pupils can also look for different ways in which bones are joined together and compare turkey bones with human bones.

For directions on assembling a turkey or chicken skeleton, see the article "Making a Chicken Skeleton" (N&S, *May 1, 1964)*, also available in N&S Resource Study Unit #101, *Animals Through the Ages.*

Flowers and Elk

This WALL CHART gives some examples of how natural selection guides evolution and emphasizes the importance of reproduction in the workings of natural selection. When people think of natural selection, they often picture a "struggle for existence," with the swiftest animals and the fastest growing plants always succeeding and passing their characteristics on to future generations.

A plant or animal may be vigorous and unusually successful in competing for food, space, or other needs, but it may not be able to reproduce itself as well as other less vigorous organisms. Natural selection depends on the ability of organisms to leave offspring. Only through successful reproduction can characteristics such as swiftness be passed on to future generations.

This fact accounts for the great variation in means of reproduction found among plants and animals. The goal of reproductive success can be achieved in several ways—for example, by increasing the chances of bringing together male and female sex cells; by increasing the chances that a fertilized egg will survive until birth; by increasing the number of sex cells. Different organisms are adapted in different ways that help achieve these goals. One example is the ways in which flowers are pollinated (*see "How Pollen Gets Around,"* N&S, *May 17, 1965, also available in 22" x 34" size,* N&S Wall Chart #209).

Fingerprint Detective

Here is a bit of fingerprint detection you can perform in the classroom with some crystals of iodine. This chemical is available from a pharmacist, but you will probably have to supply proof of your identity and sign for the purchase, since iodine crystals are poisonous.

Latent fingerprints on paper can be revealed with iodine fumes. Heat about six crystals of iodine in a test tube half filled with water. The iodine will fume when the water boils; *these fumes should not be inhaled.* If a piece of paper with latent prints is waved in the iodine fumes, the fingerprints will appear as purple lines. This is because the moisture in the latent print dissolves some of the starch in the paper, which turns the typical blue-black color in the presence of iodine.

Take an untouched sheet of paper and write the numbers 1 to 10 around the edge. Tell someone in the class to touch one of the numbers when you leave the room. When you return, you can test each number with iodine fumes.

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WCT-6

Probability and Your Pupils

(continued from page 1T)

give more reliable information; but in this case maximum certainty would not be important. What other "important" and "unimportant" measurements can your pupils think of?

3. *The available resources.* A shortage of people to do the work may influence the size of an experiment. Ask the class to imagine how many people might be put to work in a study of this question: Does what children eat have anything to do with how often they are absent from school? Help your pupils compare the number of people needed to keep track of what children eat as opposed to the number needed to keep track of what laboratory animals eat.

The size of an experiment may also be influenced by shortages of materials, such as rare drugs or rare occurrences (quintuplets, or volcanic eruptions, for example). Have your pupils think of other examples.

Sample sizes are also restricted where testing uses up the test objects. For example, if every sky rocket were pretested to see if it worked, what would be left for a 4th of July display? Your pupils can probably think of other such examples (testing flash bulbs, testing bandages for sterility, taste-testing candy, crashing cars to test their safety features).

Testing Polio Vaccine

The 1954 field test of poliomyelitis vaccine is an example of an experiment that had to be very large. In the first place, the number of cases of the disease was known to vary greatly from year to year and from place to place. Second, it was important to achieve reliable results. Also, the effectiveness of the vaccine would also influence the size of the experiment needed, and this was not known in advance.

Statisticians helping to plan the test estimated that it would be necessary to vaccinate between 100,000 and 700,000 children. A goal of 500,000 to 1,000,000 was set. However, there was only a limited amount of vaccine and time available, and there were also dropouts from the program. The final number receiving the full series of shots was a bit over 400,000 (not counting controls). Fortunately, the effectiveness of the vaccine was high enough to be shown clearly by this sample ■

nature and science
TEACHER'S EDITION

VOL. 4 NO. 6 / DECEMBER 5, 1966 / SECTION 1 OF TWO SECTIONS

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USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

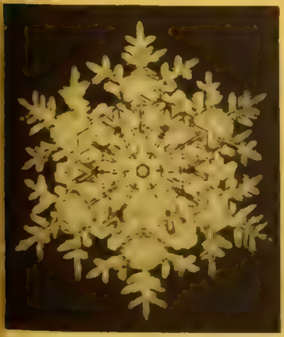
Scientists on Ice

The author's excellent photographs of scientists at work on and in the Blue Glacier should stir your pupils' interest in how and why these vast rivers of ice are being studied.

Topics for Class Discussion

• *What happens to the snow from a heavy fall over a period of a week or two?* When snow first falls, it is light and fluffy (unless warm air near the surface has partly melted the flakes). Each flake is a crystal of ice with a feathery shape *(see photo)* that leaves plenty of room for air in freshly fallen snow. Over a few days, the snow settles downward, forcing out some of the air as the flakes are packed together. More snow piled on top—whether from a shovel or another snowfall—packs the snow below even more tightly.

Bright sunlight melts the surface snow, and the melt water seeps down into the pile. At night, or when the sun is hidden, the melt water refreezes, changing the snow into grains of ice that are rather loosely packed. A crust of ice usually forms at the surface. On sidewalks, the pressure of people's boots and shoes repeatedly melts and packs the snow so that it often changes into a solid mass of ice. In a glacier, it is the pressure from the snow above that changes the lower layers into ice.



A snowflake is a single crystal of ice; no two are shaped exactly alike.

• *Why don't glaciers form in all mountainous areas where snow falls?* There must be enough snow each year so that some survives the summer melt. Mountains in New England and many in the West, for example, are snow-covered in winter but bare by summer.

• *Why must so much snow pile up before a glacier begins to flow downslope?* Snow is relatively light in weight, even when tightly packed, and when it is packed onto the rough surface of a mountainside, it tends to stick there. (Sometimes huge pieces of snow break off and fall downslope, knocking off more pieces as they fall. This is called an *avalanche,* and is not considered as glacial movement.) It takes a great deal of snow pressing down on the layers of granular ice to change them into a mass of solid ice, and then to press this ice against the rock hard enough to melt the undersurface of the ice, letting the glacier slip over the rock on a thin film of water, a tiny fraction of an inch at a time.

• *How can the upper layers of a glacier move faster than the lower layers?* When you are riding in a car that stops suddenly, your body keeps moving forward even though your feet, braced against the floor, stop with the car. In the same way, when the lower layer of a glacier stops after each short slip, the upper layers tend to keep moving, or flowing, a little farther than the lower layer.

(continued on page 2T)

nature and science
THE UNSEEN WORLD OF PLANTS
Adventures on and in a River of Ice see page 2

IN THIS ISSUE

(For classroom use of articles preceded by •, see pages 1T, 2T, 3T.)

• Scientists on Ice
Studying a glacier is dangerous work. This article and striking photographs by the author take your pupils to the scene to find out how and why scientists are probing into a giant river of ice.

• The Case of the Pale Sparrows
Why are the English sparrows so different in various parts of the U.S.? The answer will help your pupils understand the process of natural selection.

• The Unseen World of Plants
This Wall Chart will stimulate your pupils to look for patterns in things they see every day.

From Hunting to Herding
The remains of ancient camp sites and villages show archeologists about when men began to domesticate other animals and how this changed the human way of life.

Make a Better Ice Cube Keeper
This Science Workshop introduces your pupils to the principles of insulation.

How It Works—Fireplace
What makes the smoke go up and keeps rain and dirt from coming in?

IN THE NEXT ISSUE

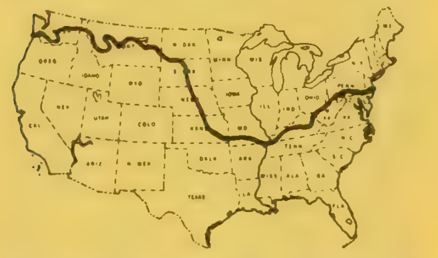
An Australian mammologist's adventurous three-year search for a rare species of possum ... Science Workshops in measuring friction and growing plants without seeds ... How men began to use metals.

Using This Issue . . .

(continued from page 1T)

- *What is the difference between a* valley glacier, *such as the Blue Glacier, and an* ice sheet, *such as the glaciers that cover Antarctica and Greenland?* Valley glaciers form on the sides of mountains and may flow down through the valleys (helping to make them by carrying off bits of the mountainside imbedded in the ice). Valley glaciers that come together in the foothills of the mountains are called *piedmont glaciers.* As a piedmont glacier thickens, the pressure from above makes it spread outward over relatively flat ground in an *ice sheet* that can cover a continent.

- The ice sheet covering Greenland reaches a thickness of more than 2 miles. It has pushed the earth's crust downward so that the center of Greenland is 1,200 feet below sea level. *Have your pupils look at a map of North America for places where the earth's crust was pushed downward by the ice sheets that covered much of the continent as late as 11,000 years ago* (see map). Hudson's Bay, in Canada, was formed in this way and filled with water from the ocean when the glacier disappeared. The Great Lakes basin was formed in the same way, and filled with water from glacial melt, rivers and streams. The bottoms of Hudson's Bay and the Great Lakes have been rising very slowly ever since the glaciers melted.

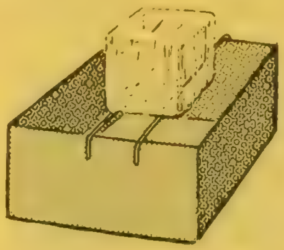


The heavy line on this map shows the southern limit of ice sheet glaciers that covered much of North America at times in the past million years.

Activities

- To show that pressure melts ice, have your pupils hold two ice cubes with the flat surfaces pressed tightly together for a few minutes. The pressure will melt ice crystals at the adjoining faces, and the melt water will refreeze, joining the two cubes into one.

- To show how ice can flow around a rock by melting and refreezing, have your pupils bend two paper clips, hang them across an open container, and place an ice cube on them as shown in the diagram. Where the cube presses against the metal, the ice melts, letting the cube slip downward around the wire. The melt water refreezes, leaving the ice in a single block.



- If you live in an area once covered by glaciers, have your pupils look for things the glaciers might have left behind: large boulders that appear to be resting on the ground, and *striations,* or parallel grooves gouged in the surface of exposed bedrock by small stones that were imbedded in the base of a glacier.

Pale Sparrows

Your pupils can probably think of some areas with strikingly different climates, and the different kinds of plants and animals that live in such areas. The article mentions some extremes, such as Death Valley and the northern California coast. But there are probably other, more subtle differences close at hand. The tops of hills and mountains are usually cooler than valleys; there are gradients of temperature and light in ponds, lakes, and seas. These gradients affect the organisms living in the environments as the organisms adapt to the different conditions.

Although the rapidity of house sparrows' evolution surprised some scientists, the different ways in which the sparrows evolved followed a familiar pattern. Many native species of animals show similar color and size variation. The variation in size, for example, is summed up in this statement, called Bergmann's rule: *Within any one species, the average size of the individuals tends to be smaller in warmer climates and larger in colder climates.*

This is a generalization, however, with many exceptions. Another such generalization, called Allen's rule, is: *Within any one species, protruding parts such as tails, ears, or bills tend to be shorter in colder climates than in warmer climates.* Having relatively small extremities, such as ears and tails, helps reduce heat loss. On the other hand, the big ears of mammals such as desert jack rabbits helps rid them of excess body heat.

Your pupils can find examples of this phenomenon by looking at the illustrations in mammal field guides. Have them look particularly at the tail length of rodents (such as mice) and the ears of such mammals as foxes and rabbits. The diagrams on page 3T show differences in ear sizes of four different kinds of rabbit.

Topics for Class Discussion

- *What's in a name?* Ask your pupils if they know of any other common names for house sparrows. In some areas these birds are called "spottsies," apparently due to the dark mark on the breast of the males. Your pupils can probably think of other animals with multiple common names; the mountain lion (cougar, panther, puma) is a good example. This is an opportunity to point out the value of a single scientific name that is recognizable everywhere in the world. The scientific name of the house sparrow is *Passer domesticus.*

- *Are there other known examples of rapid evolution?* The well-documented case of the peppered moth in England was described and illustrated in the Teacher's Edition, *N&S,* May 9, 1966. Before 1850, most of the peppered moths near Manchester, England, were pale in color. They blended

(Continued on page 3T)

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nature
nd science

VOL. 4 NO. 6 / DECEMBER 5, 1966

Can you find patterns in the things you see every day?

see page 8

THE UNSEEN WORLD OF PLANTS

Adventures on and in a River of Ice, see page 2

nature and science

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Scientis

By tunneling and drilling deep into a glacier, scientists are finding out how these vast rivers of ice flow. They are also trying to learn how to read the records of past climates that are frozen into the ice.

■ If you think of ice as something to skate on, or to
a glass of pop with, you are right, of course—but
would rate zero with the men working on Mount Olym
in the western part of the state of Washington *(see m*
These men are *glaciologists,* and to them ice means glac
the great frozen rivers that spill from mountain p
into lowland valleys.

"We have known for a long time that glaciers a
prime sculptor of the earth's surface," explains Edv
LaChapelle, of the University of Washington's Atn
pheric Science Department. "Glaciers gouge and sc
as they inch along. Now we know that they also a
frozen record of climate, and even a key to understan
the earth's structure. All we have to do is learn hov
'read' the record—but that's not easy."

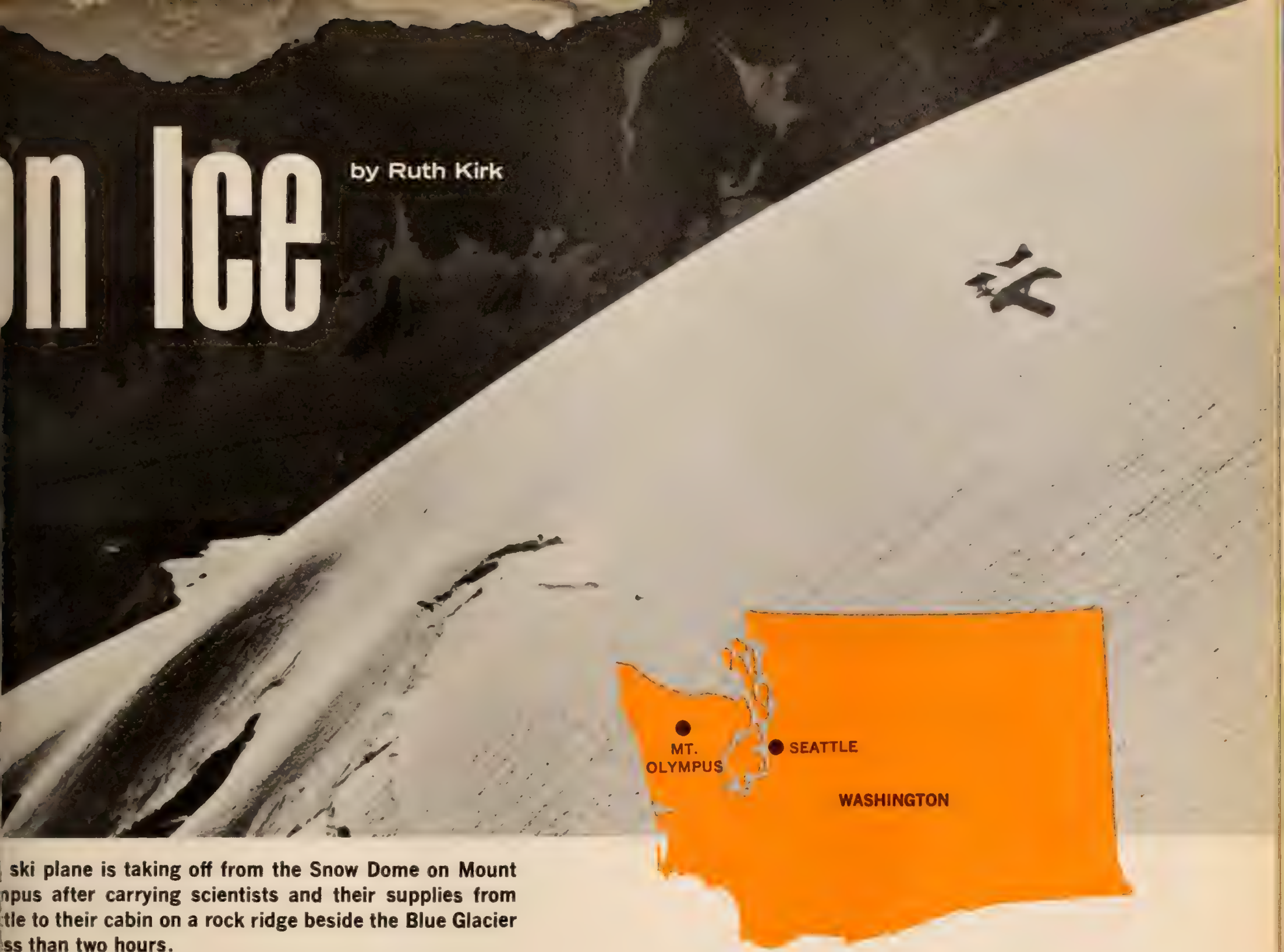
Since the International Geophysical Year, 1957
when scientists all over the world cooperated in studie
the earth, the Blue Glacier on Mount Olympus has be
station for studying the records locked in the world's
Each year both the University of Washington, in Sea
and California Institute of Technology, in Pasadena, l
sent a team there. The location is ideal; most glac
are much harder to reach *(see photo).*

What Makes a Glacier?

The Blue is one of six glaciers on Mount Olympus,
one of 60 in the Olympic Mountains. So much ice is
prising in these mountains, because the Olympics r
only 7,965 feet at their highest point, Mount Olym
This is usually not high enough for glaciers to form s
south of the North Pole. However, the Olympics ris
sharply from the Pacific that storm clouds sweep from
ocean to the peaks in only 30 miles, bringing vast amo
of snow each year.

n Ice

by Ruth Kirk



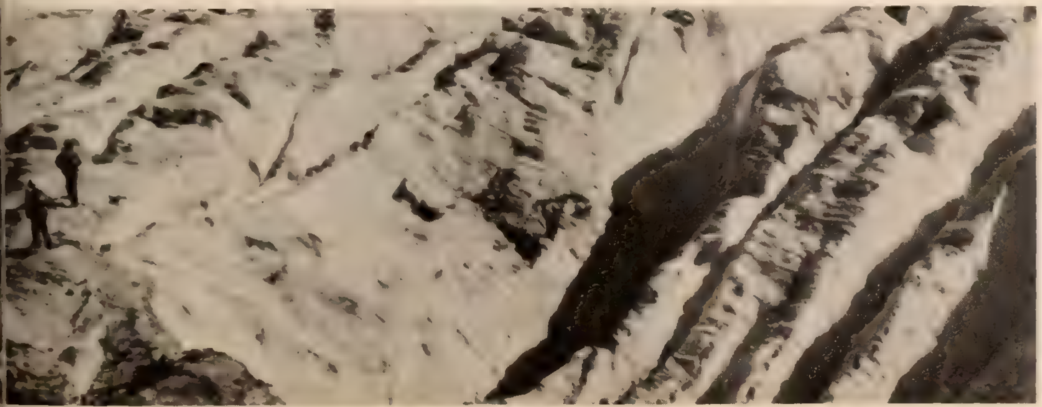
ski plane is taking off from the Snow Dome on Mount npus after carrying scientists and their supplies from tle to their cabin on a rock ridge beside the Blue Glacier ss than two hours.

he clouds cool as they rise, and some of the tiny water plets that make up the clouds freeze into ice crystals. er droplets freeze on these crystals, which fall as snow if they pass through warmer air near the ground– ain.

lore than 140 inches of rain fall on the lowland forests year, producing a lush growth of enormous trees are upholstered with moss and ferns–the Olympic n forest." At higher elevations most of the moisture falls as snow—about 800 inches a year before it settles. (A single storm once buried the scientists in their cabin beneath 14 feet of fluffy white!)

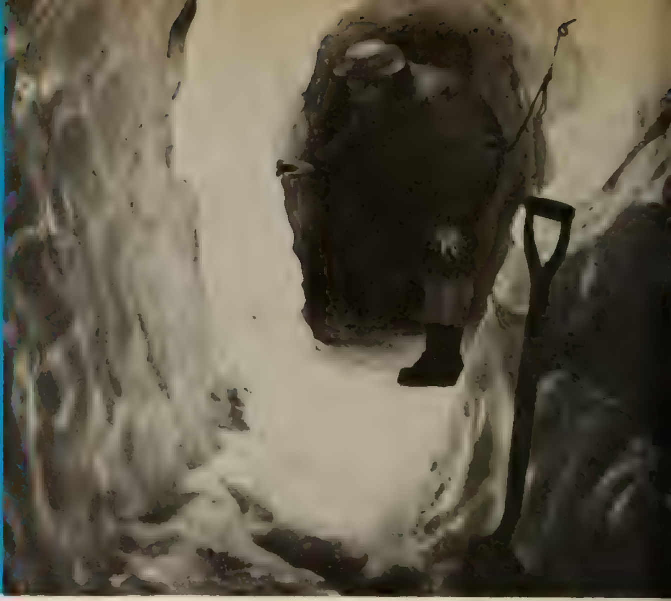
More snow falls each year than melts, and this is the reason for the Olympics' low-elevation, mid-latitude glaciers. Whenever the snow builds to a depth of about 150 to 200 feet, its bottom layers begin to flow slowly down the slope. Meanwhile, melt water is dripping down from

(Continued on the next page)



Deep crevasses make travel on the glacier dangerous. The scientists always wear crampons — hinged-steel frameworks with 2-inch teeth — on their boot soles and use an ice axe — a double-headed pick with a steel spike at the end of the pole — to find solid footing or to chop steps in the ice.

1



**1. A scientist enters the tunnel dug 160 feet into the glacier
edge of its icefall, where the movement is slow. 2. Willie St
student assistant, takes a sample of the ice from midway
tunnel. The shovel is sometimes needed to dig in — or out —**

Scientists on Ice (continued)

the surface and refreezing, and the weight of the snow above packs the snow in the lower levels together to form ice.

A glacier is not a smooth expanse of glistening white; far from it! *Crevasses,* or deep cracks, reach hundreds of feet into a glacier *(see photo),* and melt-holes cut like shafts from top to bottom. You can hear the rush of water and grinding of rocks in the bottoms of these holes, far beneath your feet where the glacier is pressing against the mountain.

Why is a glacier so broken? Take the Blue Glacier as an example. Its upper basin receives more snow each winter than the summer heat can melt, and this leftover snow feeds the glacier. As the snowflakes are buried and pushed down by more snow, they form layers of ice. The weight of these layers puts so much pressure on the bottom layers of the glacier that the ice there flows–very slowly –down the slope of the mountain.

The upper layers are too brittle to flow, so the surface ice splits, forming deep crevasses, and great blocks of ice are thrust up in a jumble. At one point, the Blue Glacier plunges over an enormous cliff in an icefall, much like a river's waterfall. Since the ice cannot bend as it goes over the cliff, it splits.

Inside a Glacier

The University of Washington glaciologists studied the movement of the glacier from the outside by observation and *time-lapse photography.* (The glacier was photographed at regular intervals of time with a movie camera set up on a rock ledge. Projecting these pictures rapidly one after another "speeded up" the movement of the glacier so the scientists could see and study it.)

Then they decided to investigate the glacier from the inside. They cut a tunnel 160 feet into the icefall *(see photos),* reaching a point where the glacier drags against the bedrock. There they put a gauge to measure how fast the glacier was flowing downslope and a second gauge, reaching from side to side of the tunnel, to measure the pressure within the ice.

"One gauge lets us watch the glacier slide down on top of us, and the other lets us see it squeeze the tunnel shut with us inside," a student assistant explained. What he said is true, although exaggerated. The vibrating needles of the gauges show that the glacier is moving about ⅜ of an inch per day downslope, and the pressure on the top and sides is shrinking the tunnel about ⅛ of an inch per day.

"By watching where the glacier pushes against a rock that sticks out at the end of the tunnel, we have learned something new," said LaChapelle. "Ice has to melt before it can move. Its pressure against the rock builds up enough heat to melt the leading surface of the ice, and the glacier slips forward over the film of water. This movement instantly relieves the pressure and stops the heating. The water refreezes, then the whole process starts again."

Continuing for centuries, this kind of movement and pressure wears away even the hardest rock. In addition, the rocks that are frozen into the bottom of a glacier act as gougers as they are dragged against a mountainside.

Digging in—and Digging Out

The tunnel into the Blue Glacier is dug into a slow-moving part of the icefall near its edge. It would be too dangerous to dig into the rapidly moving part, which

3

4

e-in. 3. Deep in the tunnel, Ed LaChapelle notes the arrange-
of a block of ice before cutting a sample for ice crystal study.
his gauge set between the ice and the bedrock at the end of
unnel measures the glacier's downslope movement.

travels an average of more than 16 feet a day. The tunnel would collapse. As it is, the men have had to dig their way in and out through cave-ins several times.

Away from the icefall the Blue Glacier moves an average of two feet per day. This is a typical rate for a *valley glacier* (one that forms on a mountain and flows down its valleys). However, a few move 100 feet a day, at least over short periods of time. The Black Rapids Glacier in Alaska once advanced three miles during a single winter (1936-37)—perhaps the fastest glacial movement ever recorded. On the other hand, glaciologists have figured out that a particle of ice at the summit of the Jungfrau in Switzerland would need 500 years to move to the end of the Aletsch Glacier, which is only about 10 miles long.

Even within a single glacier the flow varies, not only from place to place, but also from top to bottom. Before studies began on the Blue Glacier it was thought that the lower layers, which are under great pressure, must move faster than the upper layers. The California Tech glaciologists have proven just the opposite.

One summer they used electrically heated drills to force pipes 600 feet through the ice from the top of the glacier to the bottom. Each summer since then they have lowered a tiny camera into each of the pipes to record how much it has bent and in what direction. The camera is like those used in drilling oil wells. Its pictures show that the flow of the glacier forces the upper end of the pipes downslope about twice as fast as the lower end.

Glaciers are important in themselves, as well as for their records of past climates and their clues to the earth's inner structure. Enough water is locked up in the world's glaciers today to raise the level of the oceans by 200 feet if they were to melt. Nobody expects this to happen soon—or suddenly. But the climate over the world as a whole is gradually warming and most glaciers are slowly *retreating*, or melting back. A sudden, total melting, if it did occur, would flood some of the largest cities of the world—New York, Paris, London, Tokyo.

In parts of China and Russia the melt rate of glaciers has been speeded by sprinkling the ice with *loess* (windblown silt) or coal dust. The dark coating soaks up heat from the sunlight instead of reflecting most of the heat back into the atmosphere. About 13 tons of coal dust spread over a square mile of ice surface make the ice melt half again as fast, and this means more water for people to use.

In the United States, the city of Boulder, Colorado, gets water from a glacier. Tacoma, Washington, depends on runoff from the Nisqually Glacier on Mount Rainier to turn the generators that make its electric power. In Los Angeles, California, there has been serious talk of towing icebergs from the North Pacific and mooring them offshore as stores of fresh water.

Clues to Rock Flow, Records of Past Climates

Finding out how glaciers flow gives scientists some useful clues as to how rock moves around inside the earth's crust. Glacial ice can be considered a kind of rock. First of all, it is made of ice crystals, which are mineral, and rocks are made up of mixtures of minerals. Second, it is made of ice crystals that get stuck together, just as sandstone and other *sedimentary* rocks are made of grains of quartz or other mineral sediments that get stuck together. Finally, when ice crystals get down to the lower levels of a glacier, the pressure from the ice above reforms the crystals in a way that permits the glacier to flow, rather than just slide or fall, downslope. Sedimentary or volcanic rocks buried deep in the earth are often changed

(Continued on the next page)

Ray McConnell rides a canvas-bucket elevator down the 50-foot shaft the scientists dug so they could sample the ice at different layers. The aluminum ladder is there in case the electric-powered winch fails.

An opening cut in the side of the vertical shaft 20 feet below the glacier surface is the "lab" where the scientists measure the density and strength of ice samples.

Clyde Haglund measures the height of a stake sticking out of the snow on the glacier. Daily measurements showed that the snow melts in a pattern of humps and hollows across the surface, sometimes like waves on a body of water.

Scientists on Ice (continued)

by the pressures and heat there so that the rock flows, though more slowly than ice.

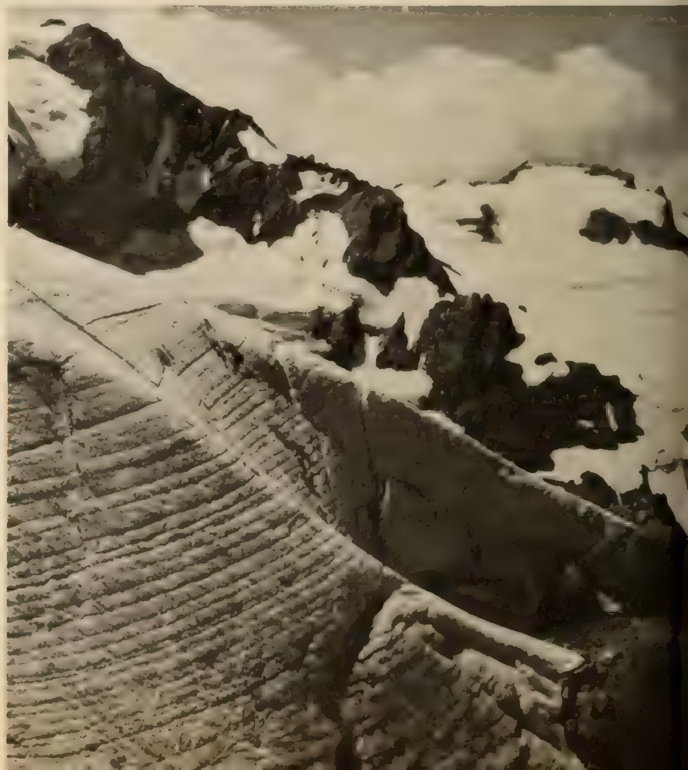
Glacial ice is a particularly convenient "rock" to study because it is at its melting point on the surface of the earth instead of deep inside, beyond scientists' reach. Also it flows faster than the molten rock within the earth, and is transparent and fairly easy to sample. What is happening within the ice thus gives clues to what happens within the earth.

Glaciers also record climate, although much more must be learned before the code is broken. "The information is right here," says Ed LaChapelle. "Each year shows in the Blue Glacier just like the *bedding planes,* or annual layers, of sedimentary rock – several feet for winter snowfall, topped by hard, clear ice from summer's melting and a dark line of windblown dust and pollen. *(See photo.)*

"If we can learn enough about exactly how snowfall and temperature and wind and sunshine affect the glacier now, while we are here studying it, then someday we should be able to relate our observations to the layers within the ice. Then we can 'read' what they have to tell about snowfall and temperature and wind and sunshine years ago, before anybody was here to think about it."

What these scientists learn from the Blue Glacier will help us learn even more about the vast *ice sheet glaciers* that cover Greenland and Antarctica. Altogether, about one-tenth of the earth's surface is blanketed with ice. If it were spread out evenly, it would cover the entire globe to a depth of 500 feet.

These are some of the reasons why glaciologists think it is important for us to find out as much as we can about glaciers—perhaps even more important than finding a way to reach the moon ■



Each of the *bedding planes,* or layers, of ice shown in this photo of the Blue Glacier represents the *net snowfall* from one year — what is left of the winter snow after the summer melt. The scientists are trying to find out how to "read" the record of climates in past years from these layers.

The Case of the Pale Sparrows

The house sparrow, often called the English sparrow, is neither English nor a sparrow. It is a weaver finch and lives not only in England but in Europe and parts of Asia. It is not closely related to the native sparrows of North America.

■ "Chirrup, chirrup, chirrup."

This is an everyday noise in many of our lives, so familiar that we don't even notice it. You can hear this sound in cities, towns, suburbs, on farms—nearly everywhere you go in North America. House sparrows—sometimes called English sparrows—were first brought to this country from Europe about 110 years ago. They quickly spread throughout the country. Today house sparrows are so common that we take them for granted. Everywhere in the country they seem to be the same plain, noisy, little birds.

But they're not all the same. Recently two biologists collected hundreds of these birds from different parts of North America. They measured and examined them, comparing them with house sparrows collected in Europe. They discovered that house sparrows on this continent are now different from those in Europe. What's more, house sparrows living in different parts of North America also differ from each other.

What accounts for these differences? Why do house sparrows in say, Death Valley, California, differ from those a few hundred miles away in Oakland or Sacramento?

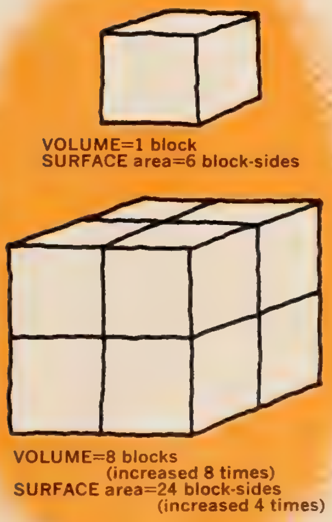
How To Succeed in the Desert

The climate of the birds' surroundings seems to be the key. Sparrows collected in hot, dry areas like Phoenix, Arizona, and in Death Valley, for example, are pale in color. So are most of the other animals of this desert country. They blend well with the pale colors of the desert and are less likely to be seen by their enemies.

When house sparrows first came to areas like Death Valley, they were probably colored about the same as their ancestors in Europe. In this dry country, however, sparrows born that were lighter in color than other sparrows had a better chance of surviving to reproduce. The pale offspring of such sparrows would likewise be more successful in reproduction than would darker sparrows. In each succeeding generation, more and more of the sparrows would be pale. Eventually, all of the house sparrows in the southwestern United States were pale in color. *(See "How Is a Flower Like an Elk?",* N&S, *November 14, 1966.)*

The climate in other parts of North America has also affected the color of house sparrows. Take places like Oakland, California, and Vancouver, British Columbia, for example. Rainfall is fairly abundant in these areas and plant life is rich and dark. Many of the native wild animals are dark colored. Such a color seems to help animals survive in these areas. The biologists found that house sparrows from Oakland and Vancouver are also dark.

The biologists found other ways in which house sparrows have changed, including certain color patterns, wing length, and body size *(see diagram)*. There is no mystery about these changes. They are simply evidence of evolution at work. But the biologists are surprised that the house sparrows evolved these differences so quickly. From studies of other animals, scientists had estimated that it usually takes 4,000 or more years for changes like these to appear in birds. The house sparrow offers proof that it can happen in a century or less ■

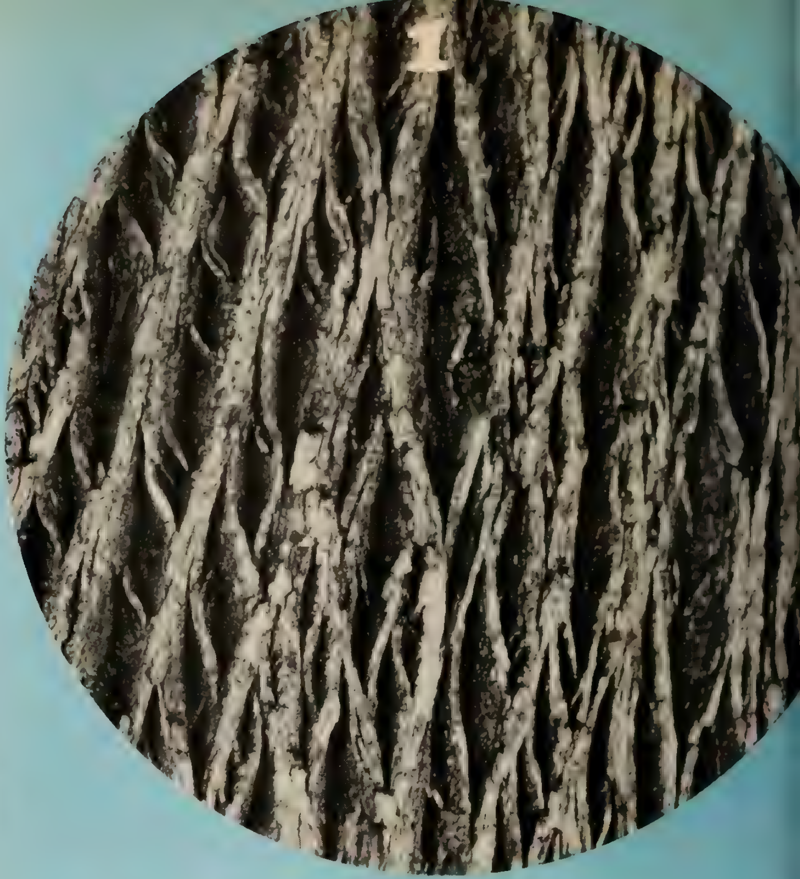


As a block gets bigger, its bulk (volume) increases faster than its surface area. In the same way, as a bird gets bigger its heat-producing bulk increases faster than the surface area of its skin. Since a bird loses body heat from its skin's surface, a big bird is better able to keep body heat than a small bird. House sparrows in the cool north are bigger than those in hot areas.

nature and science | WALL CHART

December 5, 1966

THE UNSEEN WORLD OF PLANTS

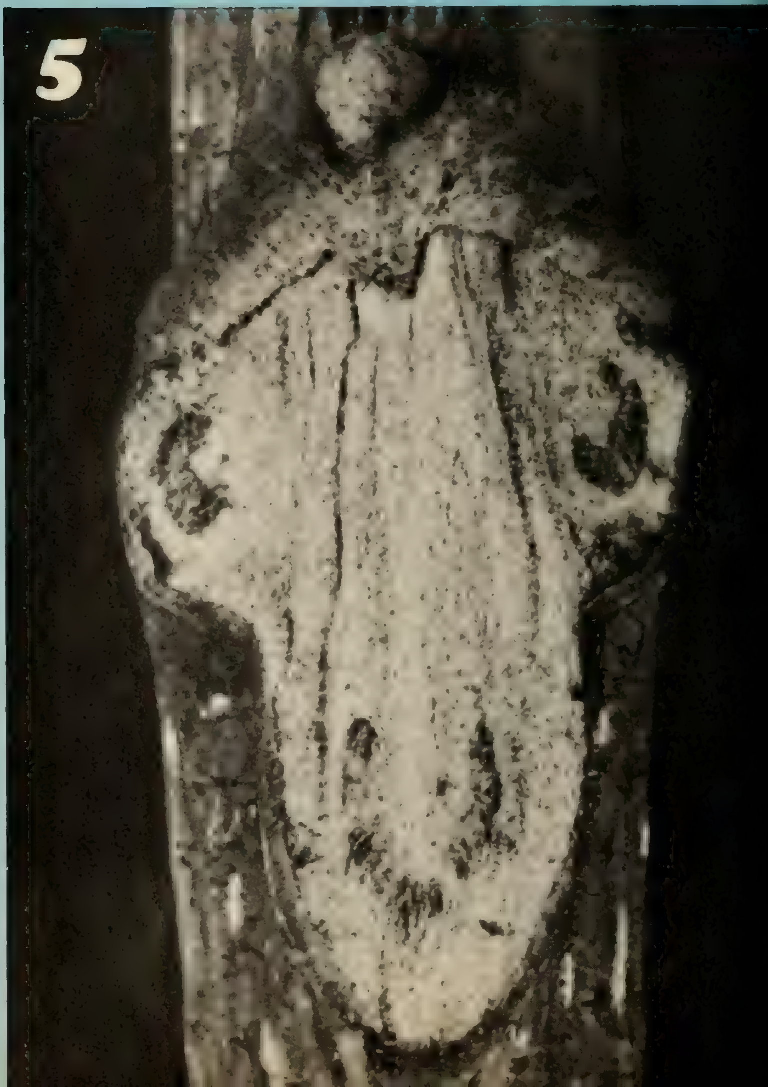


1

■ The photographs on these pages show parts of common plants. How many can you identify?

Don't be surprised if you have trouble. These views of plant parts are seldom seen by humans. To see these unusual sights, you have to bend over, kneel down, stand on tiptoe—get in close in some way. A pocket magnifying glass helps.

For the past 40 years, Dr. William M. Harlow, a professor at the State University College of Forestry in Syracuse, New York, has been getting close to plants with his camera. Some of his photos have just been published in a book called *Patterns of Life* (Harper & Row, New York, 1966, $6.95), and a few are shown here. After trying to identify the plant parts shown on these pages, read the captions (right) to check your answers. Then "get close" to some plants and discover for yourself the unseen world of plants ■



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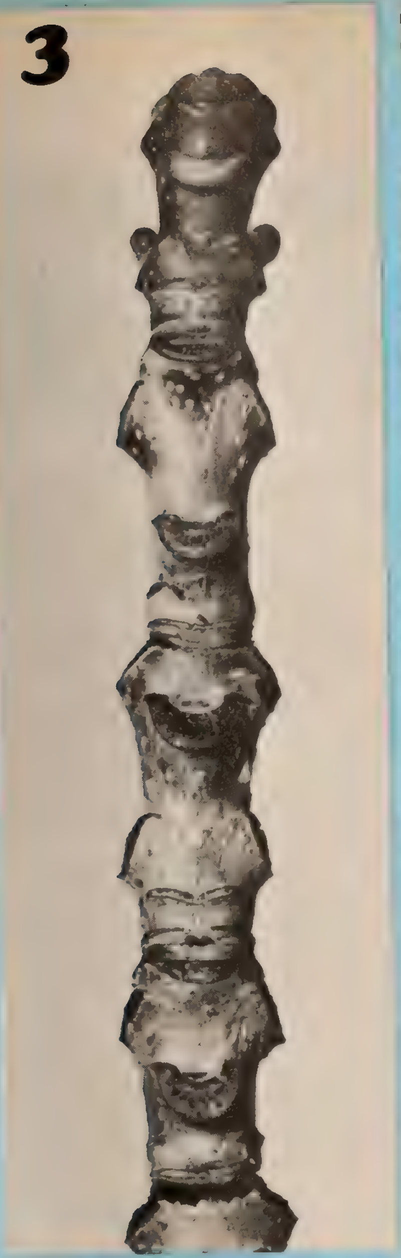
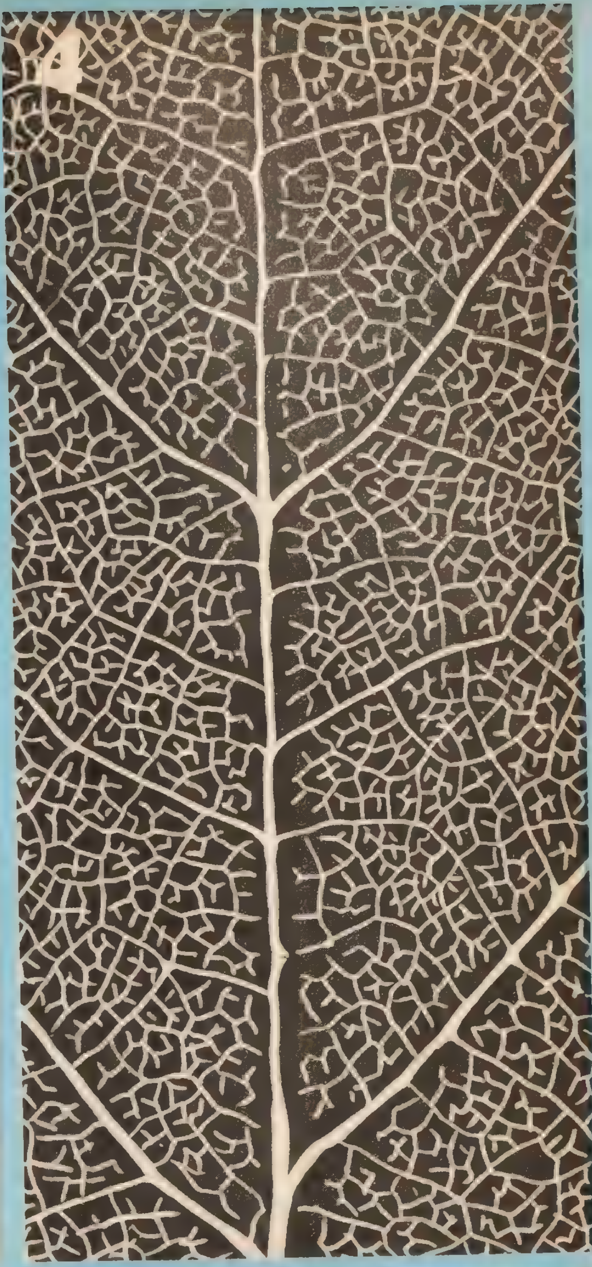
From the book "Patterns of Life"
Copyright © 1966 by William M. Harlow





**SATELLITE PHOTO OF A MOUNTAIN
IGE?** This pattern of diamond-shaped
eys and ridges is the bark of a white
tree. You can identify many trees by
r bark alone; try it.

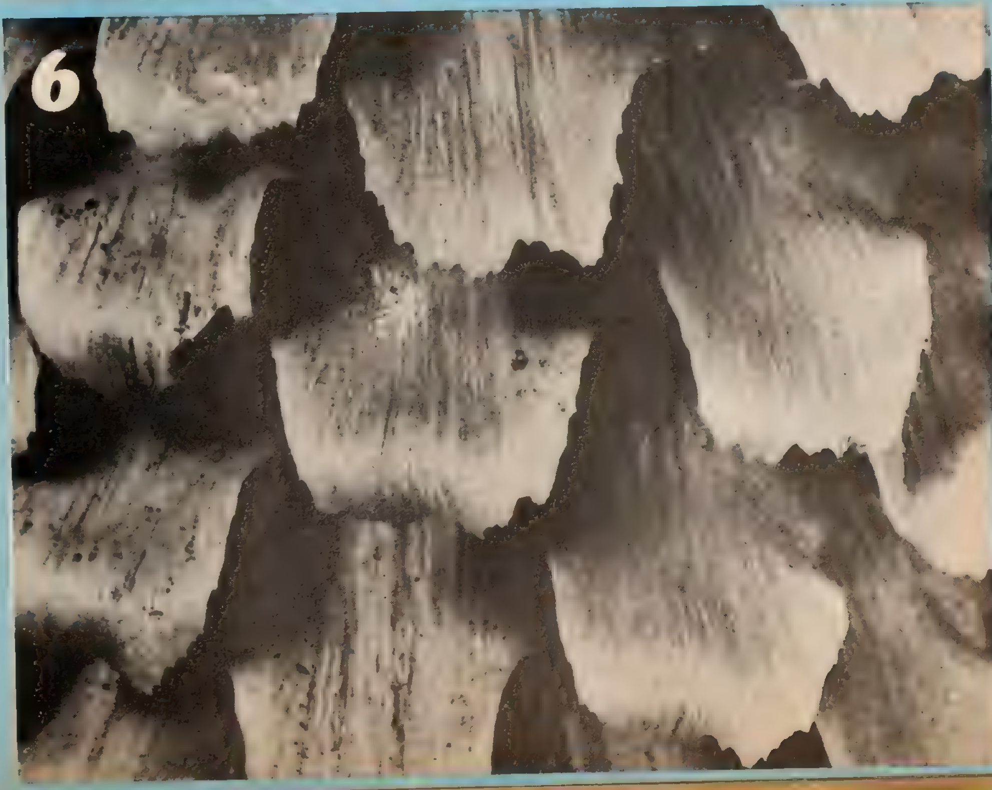
PATTERN IN CLOTH? These are the
s in a leaf of corn. Notice that the veins
parallel, while the leaves of the tuliptree
d most other trees) have branching
s. Can you find other kinds of plants
parallel leaf veins?

TOTEM POLE? No, this is a twig from
hite ash tree. Since the twig was in
p shade, it grew very slowly, leaving
ely-spaced bud and leaf scars that look
little faces.

AERIAL VIEW OF CITY STREETS? These
some of the veins in the leaf of a tulip-
. The food manufactured in the leaf
s through these veins; so do the raw
erials of water and minerals that are
d up from the tree's roots.

HALLOWEEN MASK? This is a spot on
twig of a butternut tree where a leaf was
ched. When the leaf fell off, this scar
ained. The dark markings are the ends
ubes through which food and water once
ed between the twig and the leaf. Leaf
s of other kinds of trees also have
uliar "faces"; look for them.

SHINGLES ON A ROOF? The blue
ice, a native tree of the Rocky Moun-
s, is now planted in lawns, gardens, and
s throughout most of the United States.
is a close view of the scales of a blue
ice cone. Look for seeds tucked under-
h the scales of evergreen cones.



BRAIN BOOSTERS

prepared by **DAVID WEBSTER**

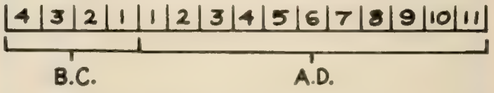
ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photos: Photograph 1 shows the inside of an eighteenth century observation tower. The sunlight coming in each window on the right side shines below each opposite window on the left side. This means that the picture must have been taken looking up. Photograph 2 is dew on the hood of an automobile.

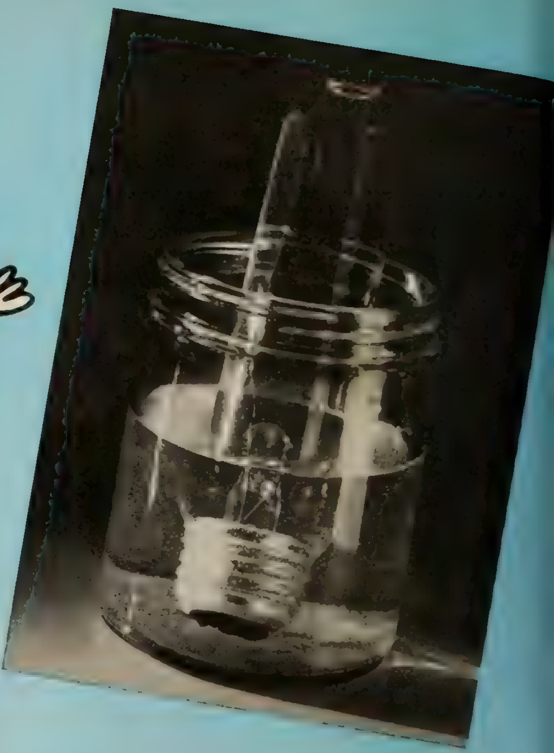
Can you do it? To find out how many gallons of water you use for a bath, first read your water meter. Then take a bath and read the meter again. If no one else has run any water, the difference between the two readings is the amount of water used. Can you find out who in your family uses the most water when taking a shower?

What will happen if . . . ? The number of complete circles made in one minute by a pendulum swinging around should be the same as the number of "round trips" made by the pendulum swinging back and forth. Will the pendulum still swing the same number of times if it were pushed just a little?

Fun with numbers and shapes: If you were born in 4 B.C., you would celebrate your twelfth birthday in the year 9 A.D. Since the use of zero was not known in those days, there was only one year from 1 B.C. to 1 A.D.

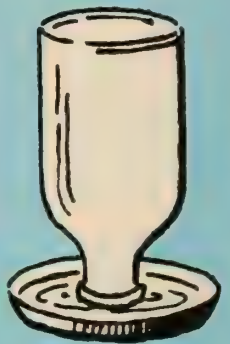


For science experts only: 1. An icicle freezes as it melts. 2. A mirror can be no smaller than one half of your height for you to be able to see yourself from head to toe.



Mystery Photo

A small hole was punched in the base of this light bulb while it was under water. Why did most of the bulb fill with water? What is in the small bubble at the top of the bulb?

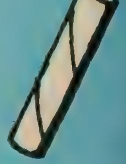


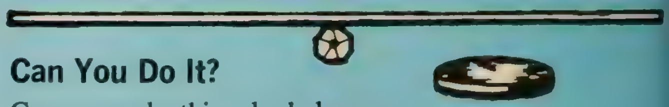
What Will Happen If . . . ?

What will happen if you heat an empty bottle with hot water, and then put it upside down into a pan of water?

Fun with Numbers and Shapes

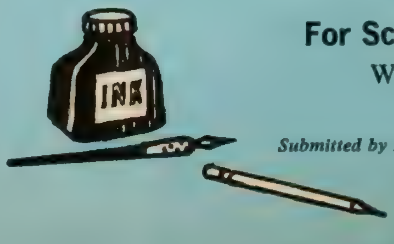
What is the shape of an untwisted cardboard tube (from a roll of paper towels)?





Can You Do It?

Can you make this ruler balance by putting only one penny on it?



For Science Experts Only

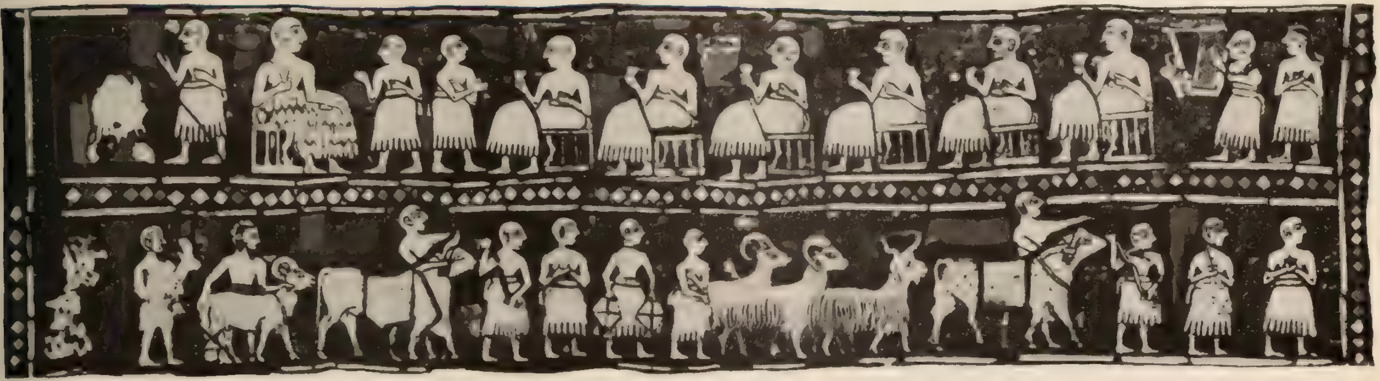
Why can you erase pencil but not ink?

Submitted by Mark Pitman, Nederland, Texas

from HUNTING to HERDING

For more than a million years people got all of their meat by killing wild game. Archeologists have found signs that men first kept and raised animals about the same time they learned to plant seeds.

by WALTER BATEMAN



This stone picture of a royal feast shows that the Sumerians (in what is now Iraq) kept animals about 5,000 years ago.

■ When your mother wants meat for supper she buys roast beef or a chicken at the supermarket. The meat is ready to cook. First a farmer raised the animals, then a meat packer killed them and cut the meat and sold it to the supermarket where your mother bought it. If you have money, you can buy meat at any time of the year.

It wasn't so easy, though, a few hundred years ago. Most people used to live on farms where they raised their own animals, and, unless they knew how to keep meat from spoiling, they had to eat all of it right then. Killing a chicken would do for one meal. Killing a pig might mean that you invited all the neighbors in for a feast. That's the way it has been for many thousands of years in Europe and Africa and Asia.

In America many Indians got all their meat by hunting wild animals up to about 100 years or so ago. In fact the way the Indians lived gives us a good idea of what life was like for our European ancestors about 10,000 years ago—before they began to raise animals instead of just hunting them.

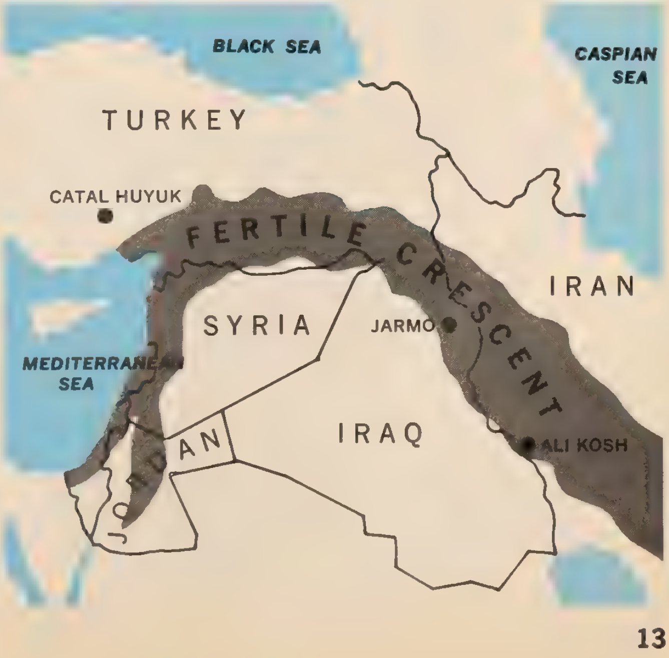
Back in those times, people got their food from wild plants and animals. If a man was hungry, he could not send his wife to the supermarket. He took his spear or bow and arrow and hunted wild game. If he missed, he stayed hungry. And so did his family.

Walter Bateman is an Instructor in Anthropology and Chairman of the Division of Social Sciences at Rochester State Junior College, Rochester, Minnesota.

Then, beginning about 8000 B.C., people learned slowly how to control their food supply by planting seeds and by *domesticating,* or raising and keeping, animals. These two great skills began in the foothills of the mountains around what is now Iraq, a region called the Fertile Crescent *(see map).*

Over the years man learned to domesticate many animals. Now we have the farm mammals that you know best: horses, donkeys, cows, pigs, sheep, and goats. In

(Continued on the next page)



the far north, reindeer were domesticated and all over the world we can find dogs. Add turkeys, ducks, geese, and chickens, and you have a list of most of the animals that man has domesticated.

The dog may well have been the first domesticated animal. At least we know that many hunting tribes used dogs. American Indians kept dogs and even gave them special burials as long ago as 2500 B.C. But we have no real evidence that dogs were domesticated before the grazing animals, such as sheep and goats. The few "dog" bones that have been found may have been from a wolf or jackal.

The early dogs may have been used for food, too. We keep dogs for pets and most people would not dream of eating them. But when early hunters got very hungry they ate what they could get.

Digging Up the Bones

The archeologists who dug up the villages in the Fertile Crescent from this early period have found many bones of goats. But how can they tell whether the old bones and horns dug up came from wild goats killed by a hunter or from domesticated goats?

How Did Men Begin To Keep Animals?

Scientists can tell about when and where men began to domesticate animals from the bones and other objects they have found in prehistoric villages and camp sites. But there is no evidence to show *how* this came about.

Scientists think that the first taming of animals—perhaps of wild dogs—came about by accident. Then, when man saw that tame animals could be useful, he tried to domesticate others, such as cattle.

Can you think of some ways in which animals like wild dogs or pigs might have first been tamed? Remember, both of these kinds of animals are sometimes scavengers, feeding on food scraps or other debris left by humans. This clue suggests one possible way that led to the taming of dogs and pigs. Can you think of others?

Even the experts are not sure. Dr. Reed says that the horns of domesticated goats today are twisted. The horns of wild goats are straight. He thinks the twist came from the breeding of goats by the men who kept them. But Reed found both kinds of horns at Jarmo, the village where very early planting was first discovered *(see "When Men First Learned To Farm,"* N&S, *November 14, 1966).* Dr. Reed thinks that the men of Jarmo hunted goats and kept goats, both.

Dr. Carleton Coon, a Professor of Anthropology at the University of Pennsylvania, in Philadelphia, dug up Belt Cave, another very early site near the Caspian Sea. He found many bones of young goats. Since hunters usually prefer to kill bigger and older animals, Dr. Coon thinks that the bones of all these young goats show that herds were being thinned out to keep the best.

At Jarmo another sort of evidence has been found: little clay figures of goats, sheep, cattle, and pigs. These are the very animals that man was learning to keep.

In Turkey, another ancient town called Catal Huyuk is being dug by Dr. James Mellaart, a Professor of Archeology at the University of Istanbul. The people there kept sheep and goats as well as cattle. But no pigs. By radioactive dating of the remains found there *(see* N&S, *November 14, 1966),* Dr. Mellaart figured out that the town was occupied between 7000 B.C. and 6000 B.C. In addition to the animal bones, he found bits of woolen cloth. He also found the round weights that were used on a stick for spinning thread. The spinning and the cloth convinced Dr. Mellaart that the people of Catal Huyuk kept sheep.

Yet it was the cattle that were most important to them. Not only did they make little clay figurines of bulls, usually with a bearded man riding, but they also put clay bulls in their temples. The temples were large and so were the bull heads with great spreading horns.

More Food, More People

With more food a society will soon have more people. More babies live. More of them grow up. The whole population soon increases. Farming and herding seem to have begun almost together. Hunters who shifted to farming and herding got a steadier and surer supply of food. Later when farmers learned to plow by hitching cattle to the plow, they could plant larger fields and grow more grain.

Farmers, of course, must live near their gardens to protect them and to work every day. Since they no longer had to wander, farmers began to build fairly solid houses of mud-bricks or stone.

Shepherds, however, wander with their flocks in search of grass. Dr. Frank Hole, a Professor of Anthropology at Rice University in Houston, Texas, found evidence that people had been keeping goats at Ali Kosh in Western Iran *(see map)* since about 8000 B.C. In the nearby mountains, he also found camp sites with the remains of the same kind of pottery that was made in Ali Kosh. He believes that during hot summers the herders—perhaps the old men and the young boys of the village—took their animals up to the mountains to find better grass.

Another difference that herding and farming made was that workers became *specialists*—people who do only one special kind of job. Just as some were shepherds and some were gardeners, Dr. Mellaart thinks that some of the workers at Catal Huyuk did nothing but weaving. The cloth he found there was of very fine quality.

In Africa, scientists are investigating the possibilities of domesticating animals such as these gemsbok *(center)* and elands *(right)*. Many parts of the African plains are not well suited to raising cattle. Native animals such as gemsbok and elands resist many of the diseases that kill cattle, and they need much less water.

The new practice of herding seems to have affected the religious beliefs at Catal Huyuk. Of course we don't know what they believed, but the villagers certainly went to some trouble to mold those huge bull heads out of clay.

Catal Huyuk also shows signs of another kind of specialist that helped make it an unusually rich village—the trader. Many of the fine tools, pieces of jewelry, and decorative objects found there are made of raw materials that must have come from other areas. The village is near some deposits of *obsidian,* a black volcanic glass that was the best material then available for making sharp knives. Dr. Mellaart believes that the town controlled these deposits and traded obsidian for other materials not found in the area.

Animals for Food, Leather, Wool, and Work

Beginning with the goat and sheep about 8000 B.C., man soon learned also to keep cows and pigs. Later, other men added horses and donkeys and camels and water buffalo and chickens and ducks and geese. In northern Europe and Siberia they domesticated the reindeer. In America the Indians of the Andes domesticated the llama and also the tiny little guinea pig. In Mexico they kept turkeys. Even some insects have been domesticated, such as the honeybee and the silkworm.

After learning to keep animals, people could live a much richer and more complicated life. Now they had a fairly sure supply of milk and meat, of leather and wool, and also of "muscle" for pulling heavy loads.

This large and reliable supply of food was needed before cities could grow. So were specialists. In cities many people work at jobs that produce no food at all. Specialists such as a weaver, a potter, a metal-worker, a soldier, or a priest all depend for food on people who specialize in farming or herding.

Scientists think that men have existed on the earth about 1½ million years. But only after they had learned to farm and herd animals about 10,000 years ago could men begin to build cities, empires, and civilizations ■

The first animal in the Americas to be domesticated may have been the llama, which has carried burdens for the Indians in South America over the centuries. Bones of llamas that lived nearly 3,000 years ago have been found at camp sites far from where the animals lived in the wild.

HOW IT WORKS

Fireplace

■ A fireplace is more than just a cave in the wall to burn logs in and a pipe to carry out the smoke. To keep the fire supplied with air, so that it burns steadily, and to keep the smoke moving up through the chimney instead of into the room, a fireplace must be shaped in a certain way and adjusted properly.

A well-designed fireplace has a back that slopes forward as it rises to a long, narrow opening that leads to the *flue,* or passage up through the chimney (*see diagram*). The long, narrow opening is called the *throat*. It can be opened or closed by adjusting a hinged metal door called the *damper*. (When the fireplace is not in use, the damper is usually left closed, to keep cold air and dirt from coming down the chimney into the room. The damper should be opened before the fire is lighted.)

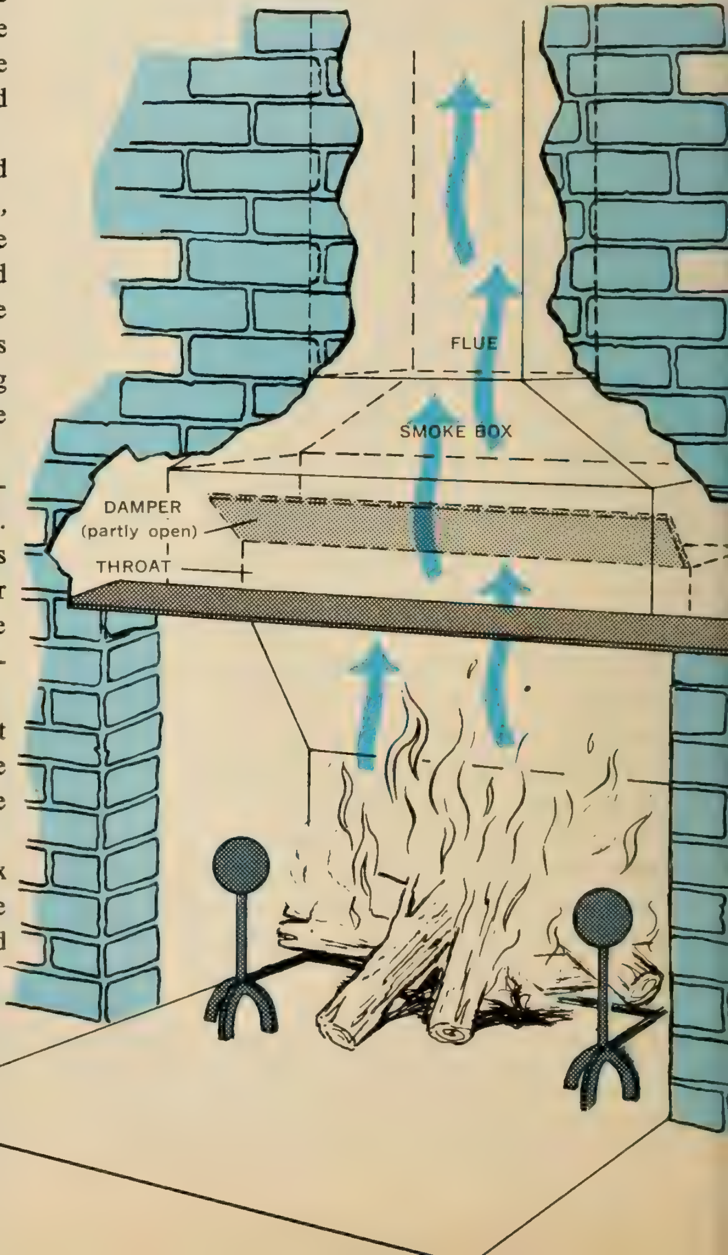
The fireplace works because when air is heated, it expands and becomes lighter than the colder air around it. The fire heats the air around it in the fireplace, and this heated air—with smoke mixed in—is pushed up by cooler air through the throat and flue and out the top of the chimney. The cool air from the room flows into the fireplace and supplies oxygen to keep the fire burning.

By adjusting the damper to change the size of the throat opening, you can control the amount of air flowing into the fireplace and out the flue. In this way, you can keep the fire burning steadily, but not too fast.

Behind the damper is a trough, called the smoke box (*see diagram*). When cool air sometimes pours down the chimney, it collects in the smoke box, where it is warmed up and moves back up the flue. The smoke box also provides a place for smoke to collect when a draft of air blows down the chimney and stops the usual flue action.

A tall chimney helps protect the fire against being disturbed by winds that swirl around the roof. Experts recommend a height of at least 35 feet from the fireplace grate to the chimney top, and the top should be at least two feet above the peak of the roof. The flue should be round or square rather than rectangular to ease the flow of air, and a cross section of the flue should have an area of at least 60 square inches.

If a house is tightly sealed, with weather stripping around all the doors and windows, the fireplace may have trouble drawing in more air, and the fire will die down. The answer is to open a window, preferably upstairs, so the incoming air will be warmed before it flows around your guests seated around the fireplace.—RICHARD M. KOFF



Using This Issue...

(continued from page 2T)

well with the lichen-covered bark of trees where they rested in daytime. But as soot and smoke from industries coated the trees and killed the lichens, the pale forms were gradually replaced by dark ones. Today the pale forms are rare except in rural areas. Similar cases have been discovered near industrial areas in this country.

Further studies may show that house sparrows have evolved rapidly elsewhere in the world. They have been widely introduced in Asia, Africa, and South America, and have probably become adapted—through natural selection—to the different environments. *(See "How Is a Flower Like an Elk?",* N&S, *Nov. 14, 1966.)*

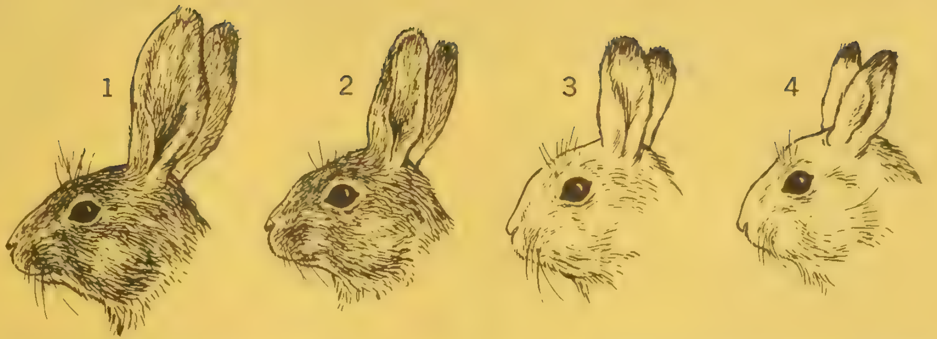
Activity

Pale color in desert animals seems to give them a survival advantage, making them less visible to their enemies. Your class can investigate the idea of animal camouflage by having a "sparrow hunt" or "caterpillar hunt," with toothpicks for animals and the pupils as hunters. This activity needn't be "kid stuff"; it offers opportunities for graphing and interpreting data.

The ideal place for this activity is a lawn or field near the school. It doesn't matter if the grass is dead, though this will affect the way in which the toothpicks are colored. If snow already covers the ground in your area, you might scatter excelsior on part of the classroom floor and have a shorter hunt with fewer hunters.

First get about 500 wooden toothpicks and cut them in half. Half of these should be left uncolored; these are *camouflaged* "animals" in dead grass or excelsior, or *uncamouflaged* ones in green grass. The other group of toothpicks should be colored, using ink or tempera paints. If green grass is available as a hunting ground, try to match the grass when coloring the toothpicks. If dead grass or excelsior is the hunting background, the uncamouflaged toothpicks should be colored red, orange, or some other color that contrasts with the background.

After coloring, the two groups of toothpicks should be thoroughly mixed and scattered over the hunting ground (before class). The pupils should not trample over the ground where the "animals live," so mark off a hunting ground as a long strip, say, 60 by 1½ feet. Then the entire class can line up along the edge and each pupil can hunt the area immediately in front of himself.



Cold-climate animals tend to have smaller ears than those in warm climates, thus exposing less surface area to the surrounding air. The rabbits shown here are (1) the Arizona Jack Rabbit, (2) a jack rabbit from Oregon, (3) the Varying, or Snowshoe, Hare of the northern United States and Canada, and (4) the Arctic Hare.

For the hunt to be objective, it is important that the children do not know about the color difference between toothpicks. They should just be urged to pick up all the "animals" they can find, using thumb and forefinger only (not using all of their fingers like a rake). Each child should have an envelope or other container in which to put his catch.

Begin the hunt on signal and stop it after one to two minutes. Then have each child count the total number of "animals" caught and the totals of the different colors. The class totals can be shown in a bar graph that compares how many toothpicks of each color were found.

Now you can reveal that there were equal numbers of each color available and ask why "animals" colored differently from the environment were caught more easily than non-contrasting ones. Did the camouflage protect the "animals" completely?

Now analogies can be made between a hunt for toothpick "animals" and pale and darker sparrows in a desert environment. Also bring in the ideas of natural selection from the articles "How Is a Flower Like an Elk?", (N&S, *Nov. 14, 1966)* and "The Hidden Animals" (N&S, *May 9, 1966).*

Unseen World of Plants

Patterns in nature have long been an inspiration to artists, designers, and architects. Some scientists put great value in the beauty of the materials with which they work; a collection of photographs taken by scientists, called "Art in Science," is now touring the United States under the auspices of the Smithsonian Institution. Watch your local newspaper for announcements of the exhibit in your area. You might even have your class present their own "Art in Science" exhibit, not necessarily with photos, but with "found objects" from nature brought in by each pupil.

Although the photos taken by Dr. Harlow can be appreciated simply for their patterns, they also reveal how plants respond or adapt to their environments. The photos can be a springboard to some winter botany projects. The captions mention, for example, that different kinds of trees have distinctive bark patterns and leaf scars. These can be studied on a field trip around or near the school grounds. With closeup lenses (available even for simple cameras) photos can be taken of bark patterns and an exhibit made of these identification clues. The references listed below will help you study and identify trees and shrubs in winter.

References

- *Trees,* by Herbert Zim and Alexander Martin, Golden Press, New York, N.Y., 1956, $1 (paper).
- *Common Trees and Their Twigs,* an Audubon Nature Bulletin, available for 15 cents from the National Audubon Society, 1130 Fifth Avenue, New York, N.Y. 10028. (You might ask for the complete list of Audubon Nature Bulletins.)
- *Investigations with Plants,* N&S Resource Study Unit #103, includes an article on twigs in winter and what can be learned from them.

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Author David Webster (known to NATURE AND SCIENCE readers as "Mr. Brain-Booster") is an elementary school science teacher now on the staff of Elementary Science Study of Educational Services Incorporated and a frequent contributor of articles to NATURE AND SCIENCE.

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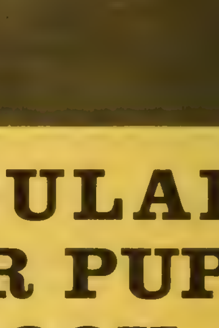
If an egg is dropped into water it will sink. What can you do to make it float? (illustration) p.76



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nature and science
TEACHER'S EDITION
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Teaching Science in the Elementary School . . .

from answers by Paul F. Brandwein to questions most frequently asked of him by elementary school teachers, supervisors, principals, and curriculum directors. Dr. Brandwein is a teacher, scientist, author, lecturer, and consultant in curriculum and method to elementary, junior, and senior high schools. Presently Director of The Pinchot Institute for Conservation Studies in Milford, Pa., and Adjunct Professor of Education at the University of Pittsburgh, he is also Chairman of the National Board of Editors of N&S.

■ **Q. If one states the concept around which a lesson is planned, should the processes to be stressed also be mentioned?**

A. Yes. A child develops a concept through experiences. Albert Einstein once broadly defined science as "experience in search of meaning." Yet, to develop a lesson around processes — observing, hypothesizing, designing investigations, and so on—without regard to products of thought and experience seems to me to lack direction. That is, giving a child experience without placing that experience in a meaningful framework is giving him experience without regard to meaning. The processes of the scientist—or the processes children use —cannot, to my mind, be divorced from the concept (a product) in which the experience is centered. This is supported by work done in the field of conceptual psychology.

Q. How do you use the terms "concept" and "conceptual scheme"?

A. A conceptual scheme is essentially a controlling idea for the organization of the content (concepts and supporting data and experiences) in a curriculum. Conceptual schemes are derived from patterns of concepts. A concept may be defined as a mental construct developed through analysis of experience isolating the common attributes of objects and events. Thus "bird" is a concept. Perhaps I should say "birdness" is a concept.

Q. I take it you feel that a curriculum ought to be structured around conceptual schemes and concepts. Why not topics?

A. In terms of the curriculum, a topic, at first look, seems to unify what appear to be diverse elements or separate events. That is, it seems to isolate common attributes. But this is not really so. For example, what does the topic "weather" or "compounds" mean? What do the topics "cover"? The topics have no limit in the curriculum sense; they are not controlling ideas.

If, on the other hand, a curriculum is structured in terms of conceptual schemes, approached through development of succeeding concept levels for different stages in curricular development, then teachers can base their teaching on carefully selected sequential experience rather than random experience. This will mean that while children and their teachers have a unified framework in which to work, they also have a true curriculum—one that does not repeat itself but one that continually expands.

Q. Then you are also saying that conceptual schemes and subconcepts (if this is an acceptable term) stabilize the curriculum, but that this is not true of a topical structure?

A. Yes. Conceptual schemes remain relatively stable over a long period of time. Experiences can and do and should change. Yesterday we were concerned with atomic energy; today we are concerned with space exploration and DNA; tomorrow it may be the sea, the nature of life. This is fine and exciting. But in a curriculum, what is needed is a relatively stable structure—a conceptual structure —into which new data may be organized.

Q. Assuming we take care of the better student, can we find some common ground on which less able students and the better ones can meet? Can we also at the same time challenge the better student?

(Continued on page 3T)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **On the Trail of Wyulda**
A persistent Australian scientist recounts his adventures in search of a very rare animal.

● **Measuring Friction**
Your pupils can discover some of the factors that make the force of friction different as surfaces of various kinds and areas rub together.

How Ice Changed the Land
Residents or visitors in the northern part of the United States can find these landscape features left by the Ice Age glaciers.

How Men Began To Use Metals
Scientists believe the discovery of metals and of how to recover metal from ore were both lucky accidents.

How It Works—Television
A simple explanation of how electron beams "photograph" an image and trace it on a TV screen.

● **Growing Plants without Seeds**
To get many plants with the same characteristics, scientists often produce them from a single plant. This SCIENCE WORKSHOP shows how.

IN THE NEXT ISSUE

A special-topic issue on diseases—what causes them, how they spread, why some become more prevalent as others are reduced . . . The continuing battle against malaria . . . Filling the "protein gap" . . . On the trail of the common cold.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

On the Trail of Wyulda

In this SCIENCE ADVENTURE, author William "Harry" Butler tells of his search for a rare Australian possum. The article can be read just for fun; it also offers opportunities for discussion of topics such as evolution, biogeography, and taxonomy.

Topics for Class Discussion

- *Why do scientists collect and save specimens of plants and animals?* The main reason is the study of *taxonomy* —the classification of plants and animals according to their presumed natural relationships. The structural characteristics of organisms—such as bones, teeth, and muscles in backboned animals — have always been important evidence in helping taxonomists discover how one organism is related to another. Today other evidence, such as behavior and blood chemistry, is also used. Some of the history and problems in classifying life were brought out in the article "When Is a Plant Not a Plant?" (N&S, *Oct. 4, 1965).*

- *What is a* marsupial*?* "A mammal with a pouch" is the first definition that comes to mind, but not all marsupials have pouches. The explanation given in the box "About the Cover" describes marsupials more accurately. The important characteristic of marsupials is not the presence of a pouch but the absence of a *placenta*—the organ in most mammals through which the mother's body provides the young with nourishment and oxygen. Since marsupials have no placenta, the young can develop within the body for only a short time and, at birth, must crawl to and cling to the *mammary glands* (from which mammals get their name).

Besides the marsupials, there is one other group of mammals that lacks a placenta: the *monotremes,* which lay eggs. The best known example of this primitive group is the platypus.

- *Why are there so many different kinds of marsupials in Australia?* The Australian continent has been isolated from other large land masses for at least 70 million years. Because of this isolation, many groups of animals and plants never reached Australia. That left many unfilled *niches,* or roles in communities of plants and animals, that were filled by the marsupials as they evolved. Bandicoots, for example, live and act somewhat like rabbits and rodents. The kangeroos, mostly grazing animals, occupy the niche that is filled by hoofed animals on other continents.

As the cover shows, some Australian marsupials have evolved in ways that give them a resemblance—as well as a role—similar to mammals of other continents. This is an example of *convergent evolution.* Your pupils might be able to think of other, closer-to-home examples of this phenomenon. Certain moths, for example, have forms, flying behavior, and feeding techniques very much like hummingbirds (*see diagram*). Mammals such as whales and porpoises, whose ancestors lived on land, have evolved forms somewhat like fishes.

Although there are many examples of convergent evolution, *divergence* in evolution, with forms becoming *less similar,* is much more common. It is the basis for the great diversity in nature. The comparison of kangaroos and hoofed animals, mentioned earlier, is a good example of how groups of mammals have evolved in different ways while fulfilling the same sort of role. Both groups are made up of grazing animals, but they are strikingly different in appearance.

- *Why did some kinds of animals reach Australia while others did not?* Some scientists believe that Australia was linked by a "land bridge" to other continents in the past. Then it was cut off and the ocean barrier kept all but a few additional forms of life from reaching Australia. The study of the geographical distribution of plants and animals is called *biogeography.* For some background material on the subject, see the Teacher's Edition, *N&S,* Dec. 6, 1965, and the article "Life Comes to a New Island," in the student's edition of that issue.

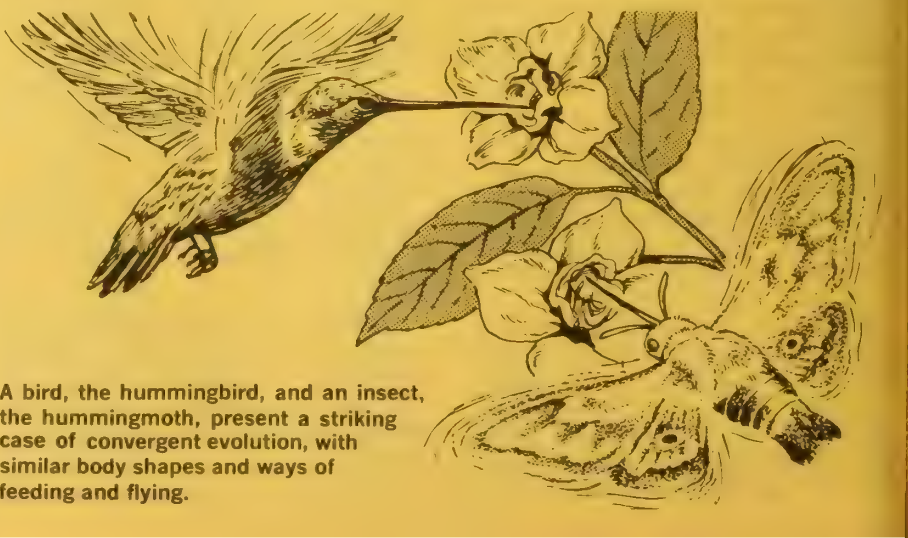
References

- *The Land and Wildlife of Australia,* by David Bergamini, LIFE Nature Library, Time Inc., New York, 1964, $3.95.
- *Kangaroos and Other Animals with Pockets,* by Louis Darling, William Morrow and Co., New York, 1958, $2.75.

Measuring Friction

In measuring the relative force of friction when surfaces of different

(Continued on page 3T)



A bird, the hummingbird, and an insect, the hummingmoth, present a striking case of convergent evolution, with similar body shapes and ways of feeding and flying.

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nature and science

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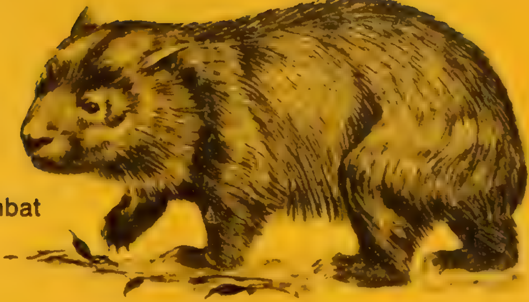
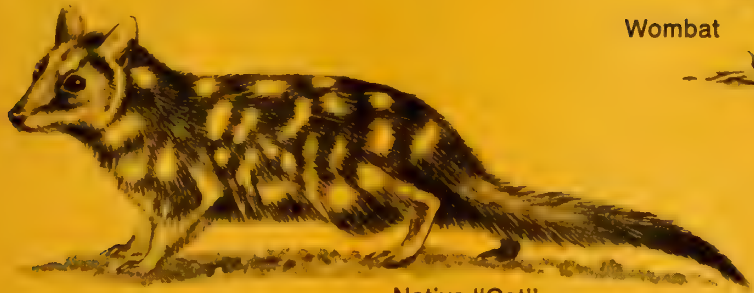
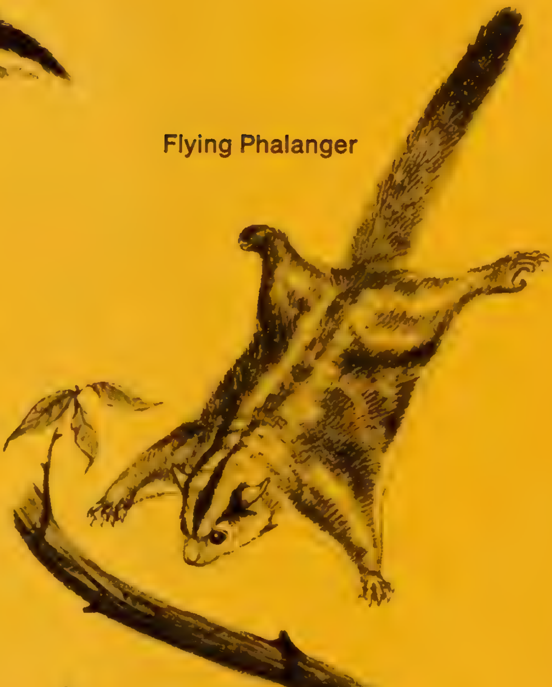
TELEVISION
How does it work?
see page 12

Why do these Australian mammals look like mammals from other parts of the world?
see "Menagerie of Marsupials," page 2



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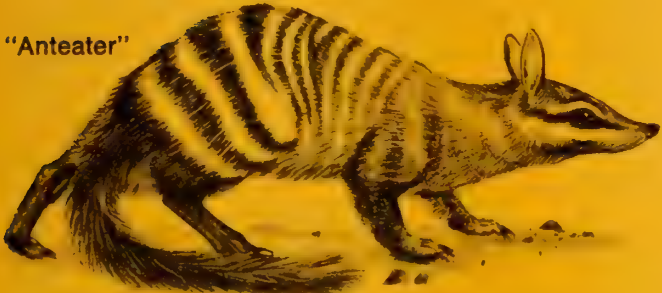
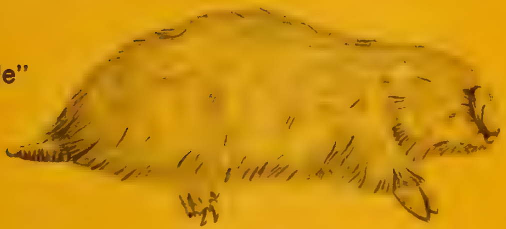
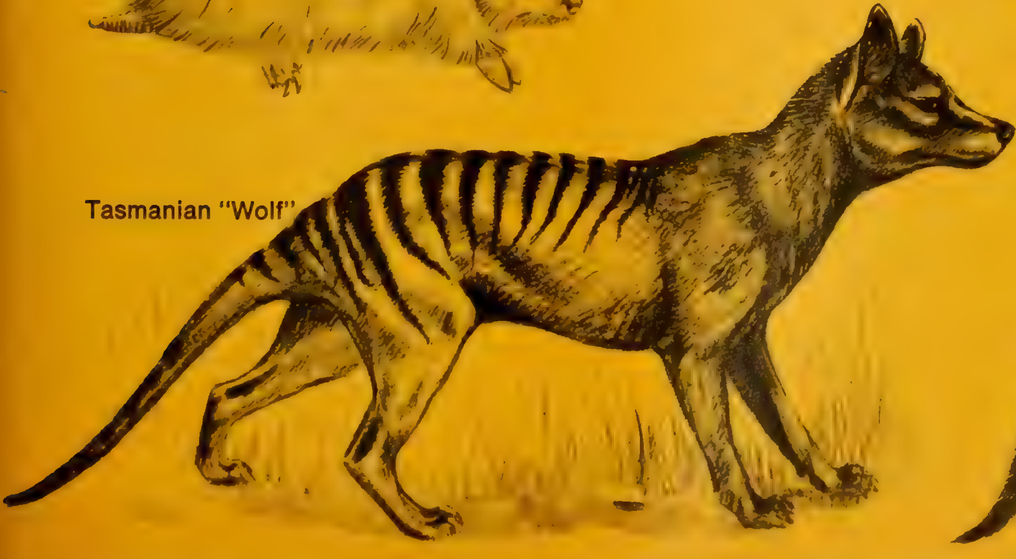
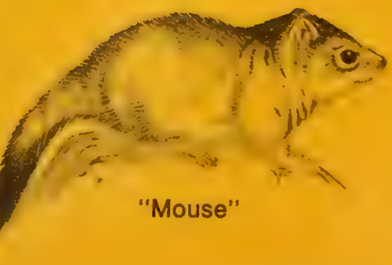





Tasmanian "Wolf"



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on th
of
Wyuld

by William Henry Butler

■ Have you ever seen a Grail? I have and not very
ago. Let me tell you about it.

In medieval times the English Knights of the R
Table under the leadership of King Arthur searche
the *Holy Grail*—a cup supposed to have been use
Jesus Christ at the Last Supper. Since then, the
"Grail" has come to mean whatever a man seeks most.

ABOUT THE COVER

Menagerie of Marsupials

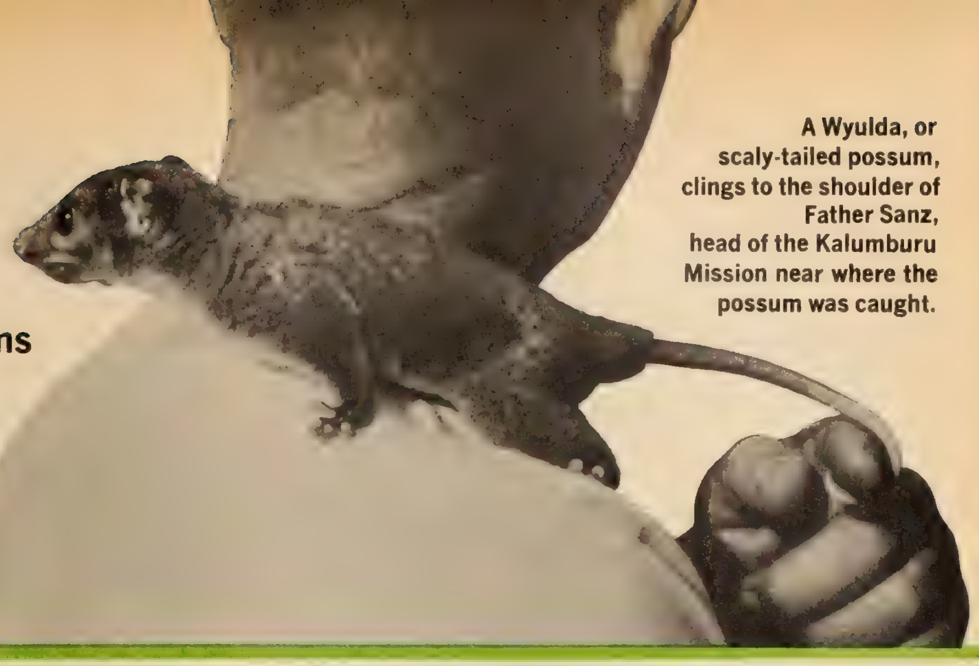
The Australian mammals shown on the cover are
marsupials. The young of these animals develop wit
in their mother's body for only a short time. The
when born, they crawl to the mother's milk-givin
nipples, usually inside a pouch of skin. The youn
may spend many weeks in the pouch before they a
able to fend for themselves.

Some of the marsupials on the cover may loo
familiar to you. They look like different kinds of man
mals that live in North America and on other co
tinents. There are marsupial "wolves," "cats,
"moles," and "mice." The wombat is like the groun
hog (woodchuck) of North America. Instead of flyin
squirrels, Australia has flying phalangers.

Why do some marsupials look like "doubles" f
mammals on other continents? The answer lies in th
isolation of the island-continent of Australia. Man
groups of mammals—such as rabbits and cats-
never reached Australia until they were brought the
by man. Marsupials, however, have lived there for
least 70 million years. During that time, almost 12
different species of marsupials have evolved. The
have adapted to surroundings that are like those o
other continents. In the process, some of the ma
supials have evolved in ways very much like mam
mals of other continents.

rail

Only four of these possums had ever been found in Australia. I set out to discover where these rare mammals lived, and to bring some back alive.



A Wyulda, or scaly-tailed possum, clings to the shoulder of Father Sanz, head of the Kalumburu Mission near where the possum was caught.

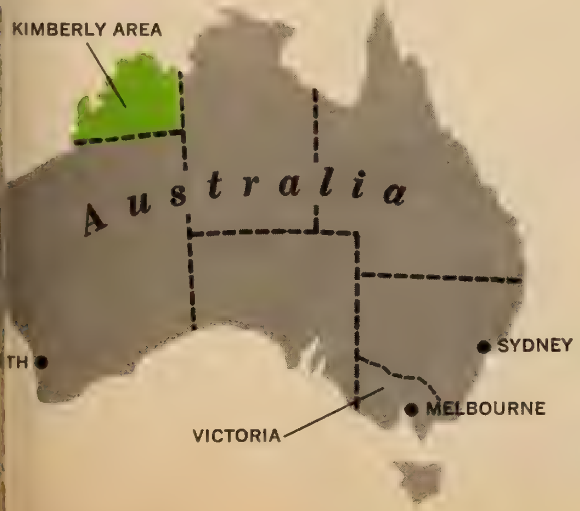
to each man *his* Grail became a different object. Some k riches or fame or honor or a prize. Whatever the ail is, it has to be almost unattainable.

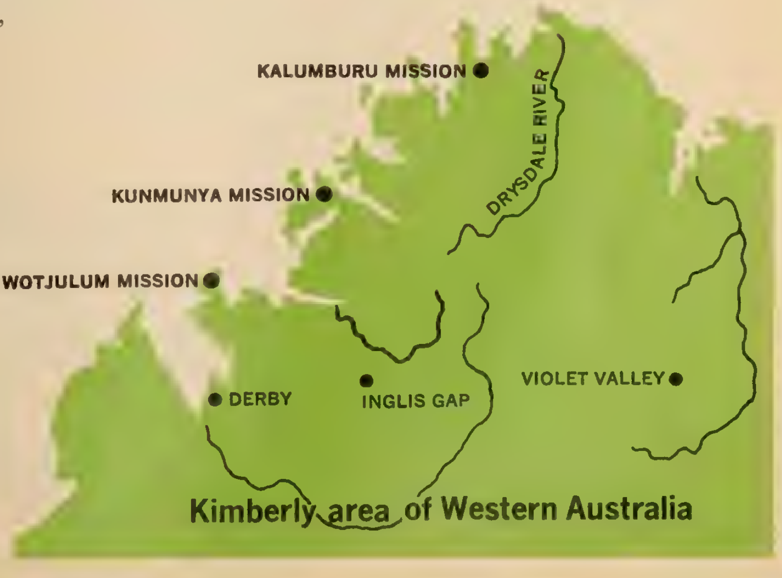
I am an Australian mammalogist (a scientist who dies mammals), and in Australia the Grail of mammal-ists has long been a member of the possum family led Wyulda, or the scaly-tailed possum. This animal s a joke among scientists and field collectors who would ntly "rubbish" each other with the question: "How ny Wyulda did *you* get?" Until 1965, only four of these imals had ever been collected

Early in the century, in 1919, the first of these animals s sent to Perth, in Western Australia, from Violet Val- , 1,200 miles to the north in what is called the Kim- rly country *(see map)*. This is cattle raising country, l it was a station owner (rancher) who captured the t specimen. A noted mammologist, W. B. Alexander, examined it and gave it the scientific name *Wyulda squamicaudata*. *Wyulda* was thought to be the name given to the animal by the Australian natives, or *aborigines*. *Squamicaudata* is a Latin word meaning "scaly-tailed." In North America, the common *opossum* has a scaly tail. It is in a different family of mammals than are the Australian *possums*. In Australia the animals we call possums have furry tails. So you can see why Wyulda was thought to be quite unusual.

In 1942, a second Wyulda was caught about 300 miles west of Violet Valley. Then, in 1954, Ken Buller of the Western Australian Museum, in Perth, collected a female with a young in its pouch at Wotjulum Mission, 100 miles south of Kunmunya *(see map)*. And so, just about a year

(Continued on the next page)





Kimberly area of Western Australia

ago, only three adults and one young of this species were known to man.

Early in 1963 I began a collection of Western Australian mammals. The specimens were to be divided between The American Museum of Natural History in New York City, and the Western Australian Museum. Neither museum had a complete collection of the mammals from that part of Australia. Mammals—and other kinds of animals and plants—are collected for museums so that scientists called *taxonomists* can study the differences or similarities in different species.

Part of the area where I would work was the Kimberly area of Western Australia. It became a gentle joke with my colleagues when I let slip my goal: to find and capture *alive* the legendary and elusive Wyulda.

Clue from a Truck Driver

I began searching in an area which ran clear across the known range of the animal. My hopes ran high when I arrived in Derby, the "capital" of Kimberly. I was told about a truck driver who had caught a "funny possum animal" and let it go. I was lucky enough to find the man, Mike Gudjerie. He told me that he and his sister had been driving at night to a lonely cattle station when this strange little animal had crossed the road and had been dazzled by the headlights. They had caught it, examined it, and let it go again.

Without giving them any sort of clue as to what I was looking for, I asked casually "Was there anything special about it?" They both replied "Yes, the tail was like a round file." Wyulda!

I made a camp in the area—a beautiful place called Inglis Gap—and started trapping and hunting among the rock ledges and crannies, searching in the hollow eucalyptus trees, and breaking open the huge red termite mounds, or "anthills," that dot the countryside. I looked anywhere a Wyulda might hide. Mike came through in his truck about 10 days later to tell me that I was on the right spot. Over a "cuppa" (a pot of tea made on the campfire), he pulled out an envelope containing a piece of fur from the animal he had caught. This was Wyulda fur—like nothing I had ever seen or felt before. I became more excited still.

As the days passed, I caught nothing unusual in my traps, but I did discover some mysterious scratches on a tree opposite my camp. Every night I shined my spotlight on this tree before going to bed. One night a pair of eyes shined back and before long I had captured a most peculiar possum. Was it Wyulda?

No, its tail was not scaly. I had found the rock-haunting ringtail, a little-known mammal which had never been collected before in Western Australia. In the same camp I caught several other mammals, including the native cat *(see cover)*, the antelopine wallaby, the gliding possum, and the rock wallaby. I had never seen or collected any of these before, and I was delighted to find them. I was very sorry, however, to leave the towering sandstone cliffs and beautiful palms and gum trees of Inglis Gap. If the scaly-tailed possum lived there, I had not found it. When I returned to Perth I faced the friendly jibes of my friends, who recalled my boast that I would catch a Wyulda alive.

"I met an animal... We didn't stop."

In November 1965, I set out on the final part of the expedition. My "hunting ground" was on the extreme northwest coast of Kimberly, near Napier Broome Bay *(see map)*. There the Spanish monks of the Benedictine

While seaching for mammals near Derby, the author set up this camp at Inglis Gap. He traveled the rugged, beautiful countryside on foot or in a Land Rover *(left)*.

Order have established a mission called Kalumburu.

The monsoon rains begin in late November in that part of Australia. I had only been in Kalumburu for a few days when the first storm of the season hit. Just over seven inches of rain fell in 48 hours. The Drysdale River rose some 17 feet overnight and the whole land ran with water. During the downpour I walked along the river's edge, looking for flood-driven animals. I caught a rich collection of reptiles, frogs, insects, and a few mammals.

Returning from such a trip one day, I was hailed by Father Sanz, the head of the Mission, who is also a fine naturalist. He had prepared a meal and called me to join him. We talked of our experiences in the Australian "bush," or wild land. Then he recalled, "About 20 years ago I was climbing a rockface, in just such a storm, when I met a peculiar animal going down. We didn't stop, but I remember his tail. It was sort of scaly."

Could this be another clue to the mysterious Wyulda? My blood was fired with the old fever. I eagerly asked the aborigines near the mission if they had ever seen these rare possums. "Wea! Wea!" was their answer. An emphatic no! There is no such beast!

"There used to be in the old days," suggested one man, but his shy comment was laughed down by the others.

The Tracks of Wyulda?

One morning at dawn, I swam the flooded creek west of the mission to see if anything had been caught in my traps. I found a half-eaten body of a granite rat, surrounded by tracks of a kind I did not know. I could tell that the tracks were made by some sort of possum, but not one that was familiar to me. Leaving the area undisturbed I went back to camp to get all the traps I had. I asked an aboriginal friend to come along. Jeffrey, my friend, shook his head over the tracks. "Dunno that one," he said.

The traps were baited and set with all possible skill and cunning and very likely a few silent prayers, too. Finally, I broke off a clump of dry grass and sprinkled it with aniseed oil. Then I dipped it in water and brushed off the whole area where Jeffrey and I had stepped or where we had touched anything. We hoped this would wipe out all trace of human scent. Then we went away.

That night it rained again, but during the height of the storm I went out into the night, swam the river, and inspected the trap by flashlight. Nothing! I returned to bed wet and sulky.

In the morning, I was up just before dawn and hurried to the traps. In one of them was a Wyulda! I danced with excitement. The wonderful feeling of having a Wyulda was the most stirring thing I have ever felt in a lifetime of collecting and studying mammals.

The author caught Wyuldas in areas like this—sandstone cliffs surrounded by thick growths of vines, sandal wood, and other plants. According to the aborigines, the Wyuldas eat leaves, insects, and the fruit of sandal wood.

But more was yet to come. The possum rolled over and hissed as I took it from the trap. When I picked it up, I could feel a squirming lump under my fingers. Then I knew that I really had two Wyulda—a mother with a young in her pouch!

I hurried back to camp and put the Wyulda in a cage. Then I tried to "play it cool" as I walked into the breakfast room of the mission where the priests were gathered. Alas for my ambition. One look at my face was all they needed. They rose and drank a toast to me—with tea!

Then we all went to look at her. She was a soft grey cat-sized animal, with big dark brown eyes. Her face was ringed by a magnificent crop of whiskers *(see photo at beginning of article)*. And the scaly-tailed possum does have a hairless, scaly tail. The aborigines crowded around, shaking their heads. They had never seen such an animal.

About mid-afternoon, an old "pehman" (witch doctor) came up the path to the Wyulda's cage. He peered in at the Wyulda and pronounced a word. The silent crowd that had gathered caught it up and it spread amongst them like ripples on a pond. "Lang... Langu... Llangul... Eelangul... Eelangool".

(Continued on the next page)

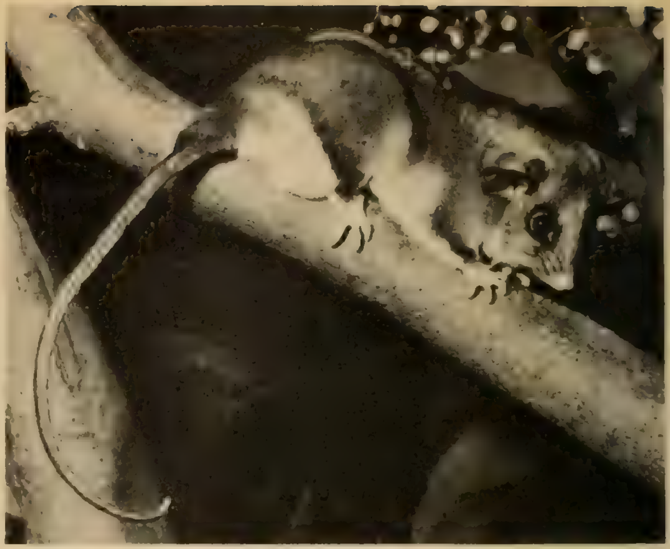
This was the possum's name among the people of the area—*Eelangool.* The pehman told me of Eelangool. He said the animals are mostly very rare, but at times they become plentiful. They live in the sandstone ledges and eat leaves and insects but mostly the fruit of a sort of sandal wood that grows among the rocks. He said the possums tasted good and that the fur was useful for making string.

"I eat this one?" He grinned as he pointed. "Not likely," I answered, rising before I realized his great joke at my expense. The camp roared with appreciation. "Wah! that was a good one!" Then he quietly sang the *corroborree,* or story song, of Eelangool with all the people joining in singing and clapping.

More Wyulda . . . and Another Grail

A few days later I caught another Wyulda, this one a male. Then the female let her young out of the pouch. I held out my hand and the little possum came to me. It was a female and seemed quite healthy.

I began to study the land where Wyulda lived, taking photographs and collecting plants and animals. Airplanes come to the mission once a month, and in January, on New Year's Day, I sent a group of live animals to the Museum in Perth. They included two Wyulda, two native cats, eight marsupial mice, and three bandicoots, as well as two kinds of kangaroos, some pythons, and tortoises. The pilot of the plane was used to carrying odd cargo but the air hostess was horrified. Within 24 hours the animals were all safe in Perth.



Until this year, the pigmy possum Burramys was known only from fossil remains. Then this Burramys was found alive. It has a four-inch-long body and a six-inch tail.

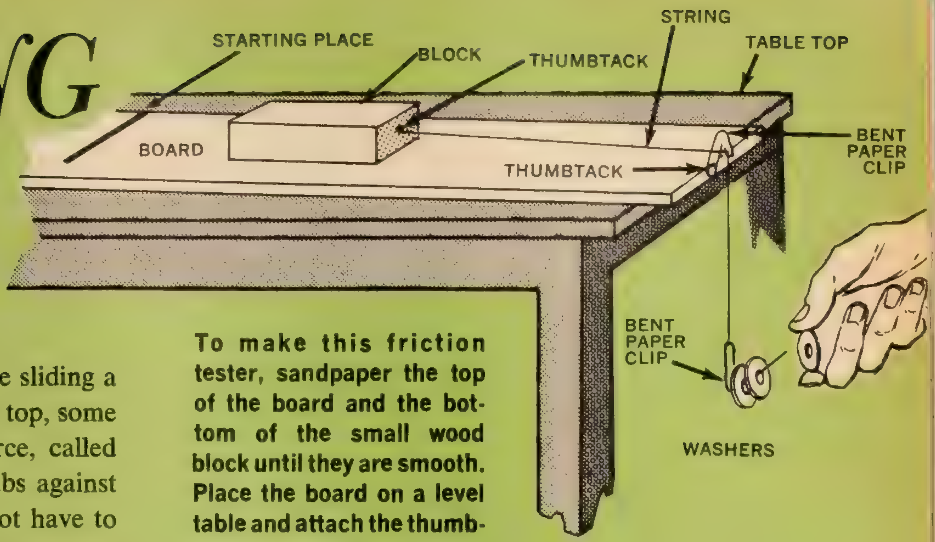
I captured seven Wyulda in the next month and then flew to Perth. I found that the mother Wyulda had died, but the young one was doing well. When last seen, the young Wyulda was eating cashew nuts at the home of Mrs. Ella Fry, a mammal artist, who was painting the possum's portrait for a new book on Australian mammals.

So I had found my Grail. But something new always challenges and beckons in science. Only a short while ago in Victoria, Australia, another sort of possum called *Burramys (see photo)* was found alive in the snow. It had been known before only from fossil bones and teeth found in caves. There are other rare mammals to be found and studied out in the Australian desert—the pig-footed bandicoot, the stick-nest rat, the sandy numbat. Another day, another Grail! There is plenty to do yet ■

The author, William H. Butler, is shown here with the skin of a kangaroo. As you read this, he is collecting and studying animals on Barrow Island, 30 miles off the west coast of Australia. An oil company will soon drill 200 oil wells on Barrow; Mr. Butler wants to discover what animals are on the island before the drilling starts. "There will be a lowering in the wildlife population," he says. "I'd like to go back later and see what effect the wells have." He also plans to do further collecting in the "bush" of Western Australia.

MEASURING FRICTION

by Robert Gardner



To make this friction tester, sandpaper the top of the board and the bottom of the small wood block until they are smooth. Place the board on a level table and attach the thumbtacks, paper clips, and string as shown. Use iron washers, all of the same size, for weights.

■ You have probably noticed that when you are sliding a box or some similar object along a floor or table top, some force seems to keep holding it back. This force, called *friction*, is always present when one surface rubs against another surface. Without friction, you would not have to keep pulling so hard—but what would keep your feet from sliding out from under you?

Perhaps you have also noticed that the force of friction is not always the same. For example, it is much easier to walk on a rubber mat than on a polished floor or an icy pavement. So the kinds of surfaces that are rubbing together seem to have something to do with the amount of friction that is present. Can you think of some other things that affect the force of friction?

With a simple friction tester (*see diagram*) you can find out which kinds of surfaces produce the most friction and investigate some of the other things that change its force. Place the block smooth-side down on the board, as shown, and hang washers one at a time on the hook at the end of the string. The number of washers it takes to make the block move is a measure of the friction holding it back.

	WASHERS NEEDED TO MOVE BLOCK OVER		
Surface on block	Wooden surface	Aluminum surface	_____ surface
Wood			
Rubber			
Aluminum			
Thumbtacks			

Testing Different Surfaces

Try taping a sheet of sandpaper to the bottom of the block and see how many washers are needed to make it move. (Keep a record of your findings on a chart like the one on this page.) Try aluminum foil, waxed paper, and construction paper. Put rubber bands around the block, or a thumbtack in the bottom of the block at each corner. Try taping a strip of foil to the surface of the board. Or newspaper. You can probably think of many other kinds of surfaces to test together.

Which surfaces produce the most friction? Which ones produce the least? ■

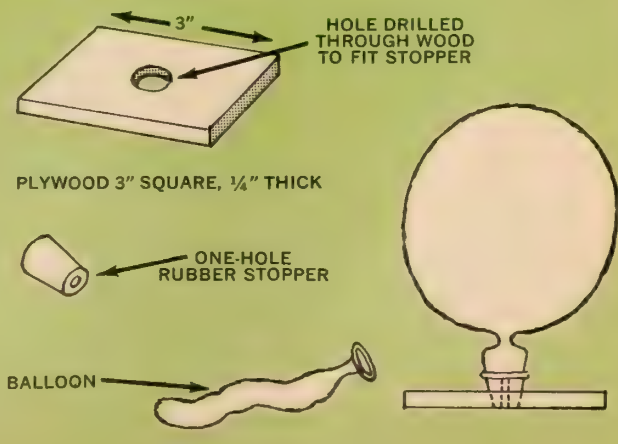
INVESTIGATIONS

1. Does the frictional force change if there is more weight pressing the two surfaces together? Does it double if you put another block of the same size on the first block?

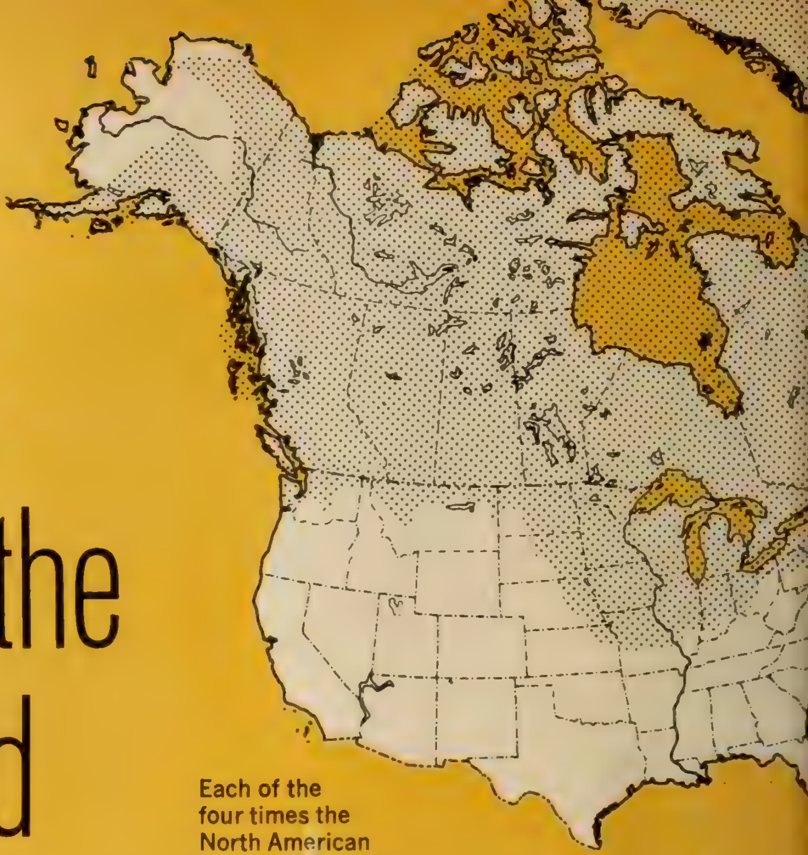
2. Does the area of the surfaces rubbing together make any difference in the friction produced? To find out, turn the block so that it rests on one of its narrow sides.

3. Does it take more washers to start a block moving than it does to just keep it moving once it has started? See if you can figure out a way to find out.

4. What happens when there is no friction? We can never design a frictionless surface, but we can come close. You might like to build a device like the one shown here. Try pushing it along a very smooth table top. How can you use it to find out whether the table is level or not?


3"
HOLE DRILLED THROUGH WOOD TO FIT STOPPER
PLYWOOD 3" SQUARE, ¼" THICK
ONE-HOLE RUBBER STOPPER
BALLOON

How ICE changed the land



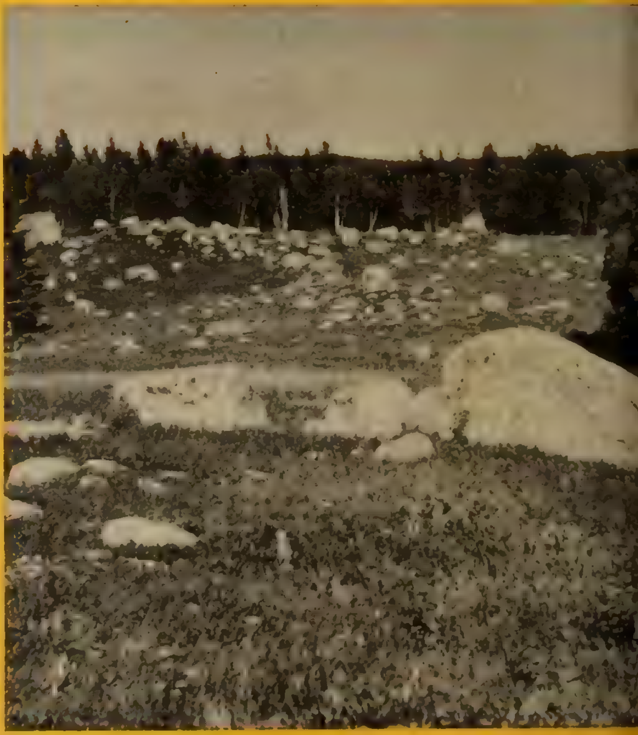
Each of the four times the North American ice sheet spread southward in the past million years, it covered most of the area shown in gray on this map.

■ Vast continental glaciers—sheets of ice thousands of feet thick—cover most of Greenland and Antarctica. An ice sheet like these covered most of North America four times in the past million years. Each time the ice sheet spread southward and retreated northward, it changed the shape of the land in what is now Canada and the northern United States (*see map*). The last ice sheet melted about 11,000 years ago.

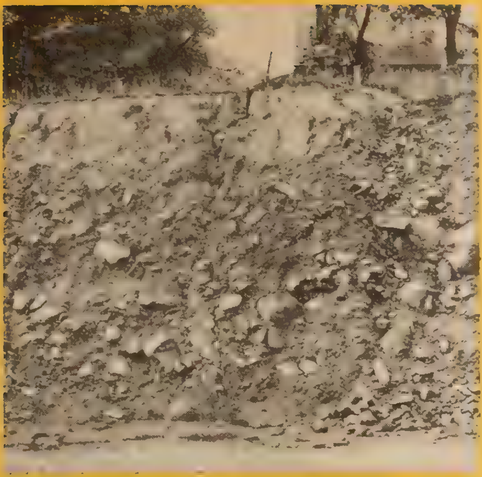
This immense ice cake pressed down the land in many places, forming depressions that filled with water when the ice melted back. One huge dent in the earth's crust was filled later by the ocean and became Hudson's Bay. Others became what are now the Great Lakes and many smaller lakes.

From the Great Lakes basin, the slowly moving ice sheet gouged out great stretches of rock and ground the rock into clay. The ice carried the clay southward and spread it over thousands of square miles of land, forming the vast midwestern plains where much of the world's wheat is now grown. In other places, when the ice melted it left rocks, sand, and clay that the ice had carried down from the north. Each time the ice sheet melted, the land it had pushed down began to rise again. The northern floors of the Great Lakes are still rising, making the water deeper along the southern shores.

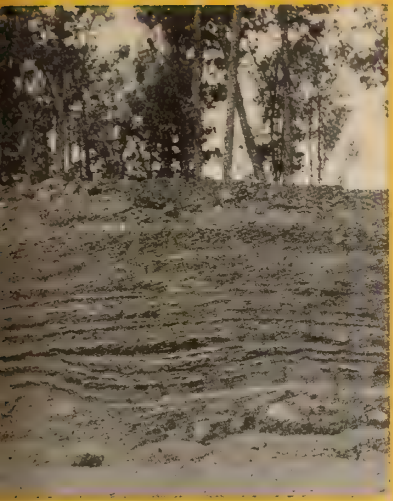
This Wall Chart shows some of the things the ice sheet left behind. If you live in, or visit, a part of the country that was covered by ice, see if you can find some of these marks of the Ice Age in North America ■



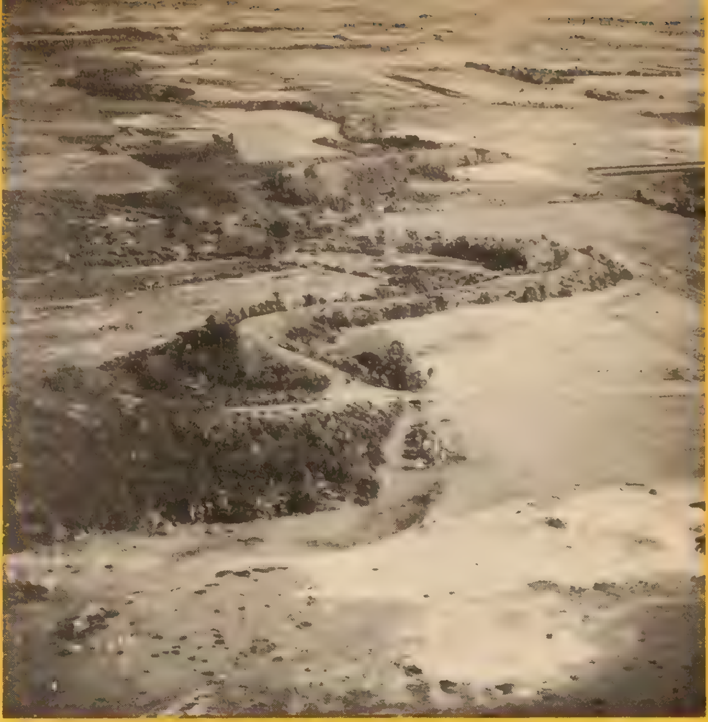
Boulders like those shown in this photo, as well as pebb sand, and clay, were carried south by the ice sheet and behind when it melted. Such material is called *drift*, beca people once believed it was left behind by icebergs that dri in the floodwaters described in the Bible story about Noah's



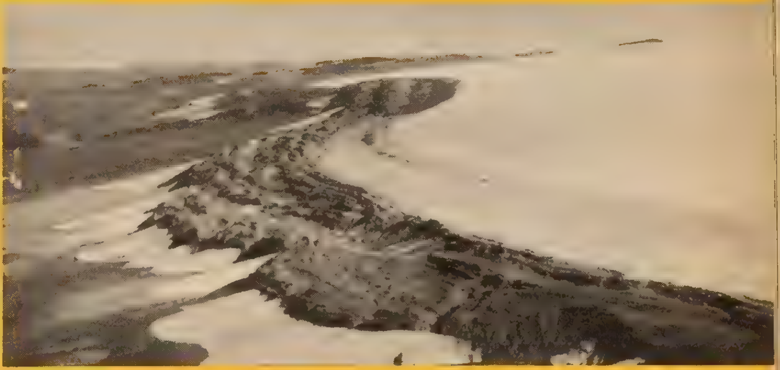
Where part of an ice sheet melted rapidly, boulders, sand, and gravel were dropped in a hodge-podge, as shown in this photo. This kind of drift is called *till*.



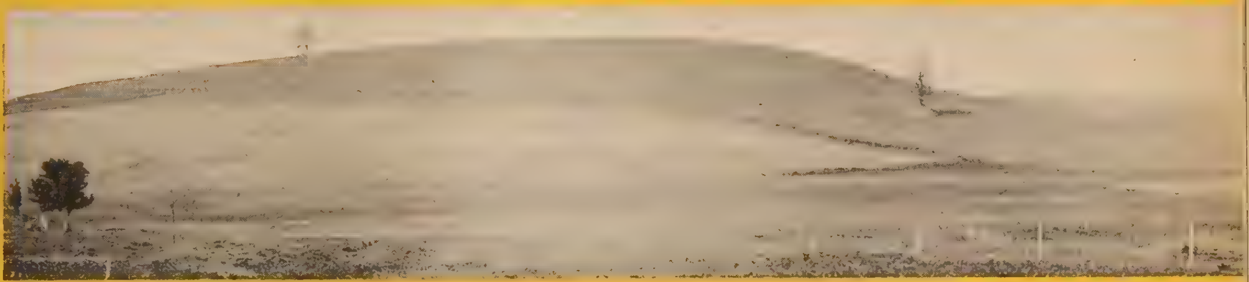
The water from slower melting ice spread the drift in layers, with most of the heavier materials at the bottom, as shown in this photo of a hill that has been cut in half.



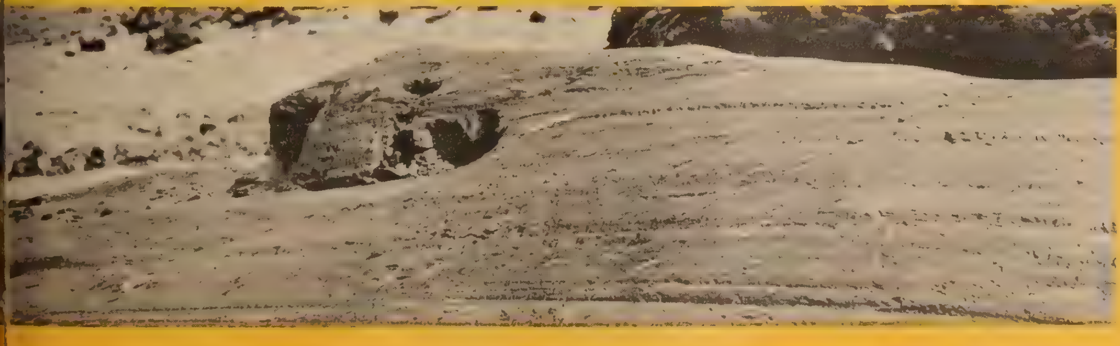
Winding mounds like the one shown in this photo were formed where tunnels that water had bored through the bottom of the ice sheet became filled with sand and gravel. These *eskers*, as they are called, may be up to 300 miles long, and they are sometimes used as paths or roads.



ill formed of drift that has piled up at the end of a glacier, or erneath it, is called a *moraine*. This photo shows the moraine t has formed at the edge of the vast ice sheet that covers most of enland today.



his streamlined hill, alled a *drumlin*, may ave been shaped when .e ice sheet passed ver a thick pile of drift. he flatter side of a rumlin always points the direction in which e ice was moving.



The scratches, or *striations*, in the surface of this exposed bedrock were gouged out by stones imbedded in the bottom of the ice sheet as the ice passed over the rock.

HOW MEN BEGAN TO

Sticks and stones and pieces of bones were about the only tools people had to work with for a million years. Some lucky accidents launched them into the Age of Metals.

■ Have you ever day-dreamed of living like an Indian out in the woods? Of building a fire without matches? Of shooting a deer with your own bow and arrow? Of skinning the deer to make your clothes and your tent?

That seems like fun as long as it is "just pretend." But it's a hard life, and for you and me it would be extra hard. First we would not know *how* to do any of those things. And second we wouldn't have any *metal*. No needle, no ax, no steel knife. To cut we would need a sharp stone.

Before people knew about metal, they cut things with sharp stones. They became quite skillful at chipping and flaking pieces of flint to make knives, axes, scrapers, and drills.

For over a million years men chipped stone tools. Even long after people began farming about 10,000 years ago, they still made tools of stone. They shaped their picks and hoes from stone and lashed them to wooden handles.

Metals in Disguise

You probably know that the metals we use come from certain kinds of rocks that are made of metals combined with other substances, such as oxygen or sulfur or carbon. When these rocks contain enough metal so that they are worth mining, they are called *ores*. An ore usually does not look very much like the metal we get from it. Iron ore, for example, looks more like rust than like shiny steel. Ore that is made of copper combined with oxygen and carbon is green, but when the ore is made only of copper and oxygen, it is red.

Once in a while, though, someone finds a reddish lump of copper in or on the ground. This is called *native copper*, and it is rare today, though it was not so rare 100 years ago. Gold is sometimes found in the form of *nuggets*, or lumps. Even native iron is found in a few places, although if you found a lump of iron in the ground, it would probably be a *meteorite* — a "shooting star" that reached the ground without completely burning up.

An early hunter who was searching the ground for flints might have picked up a shiny nugget of copper or gold. If he tried to chip such a nugget with a sharp stone, he might have found that the metal would not chip, but would change its shape, instead. Perhaps this is how the early American Indians discovered native copper.

At first they made copper arrowheads and axes. Later they made beads or bangles and other ornaments. By 2000 B.C., the Indians in what is now Wisconsin were making tools, including spearheads and knives, of copper. (The blades got dull quickly because copper is such a soft metal.) Some of these copper pieces were buried in Indian graves where archeologists have found them.

Native metals were also found in the Near East, near the Fertile Crescent, where men first learned to farm and to herd animals *(see* N&S, *October 31 and November 14, 1966)*. The iron was too hard to shape, but copper and gold were hammered into ornaments–rings, pins, and buttons–as long as seven or eight thousand years ago.

A Lucky Accident

Then men learned how to get metal from the rocks that contain it. No one knows just how or when this happened, but it was probably the result of an accident. It had to be a special kind of accident, though, for several reasons. First of all, you could never guess from the appearance of a piece of copper ore that it contains metal. Second, to *smelt* copper ore, or separate the copper from the oxygen or carbon or sulfur in the ore, it has to be heated to a temperature of about 2,000°F.

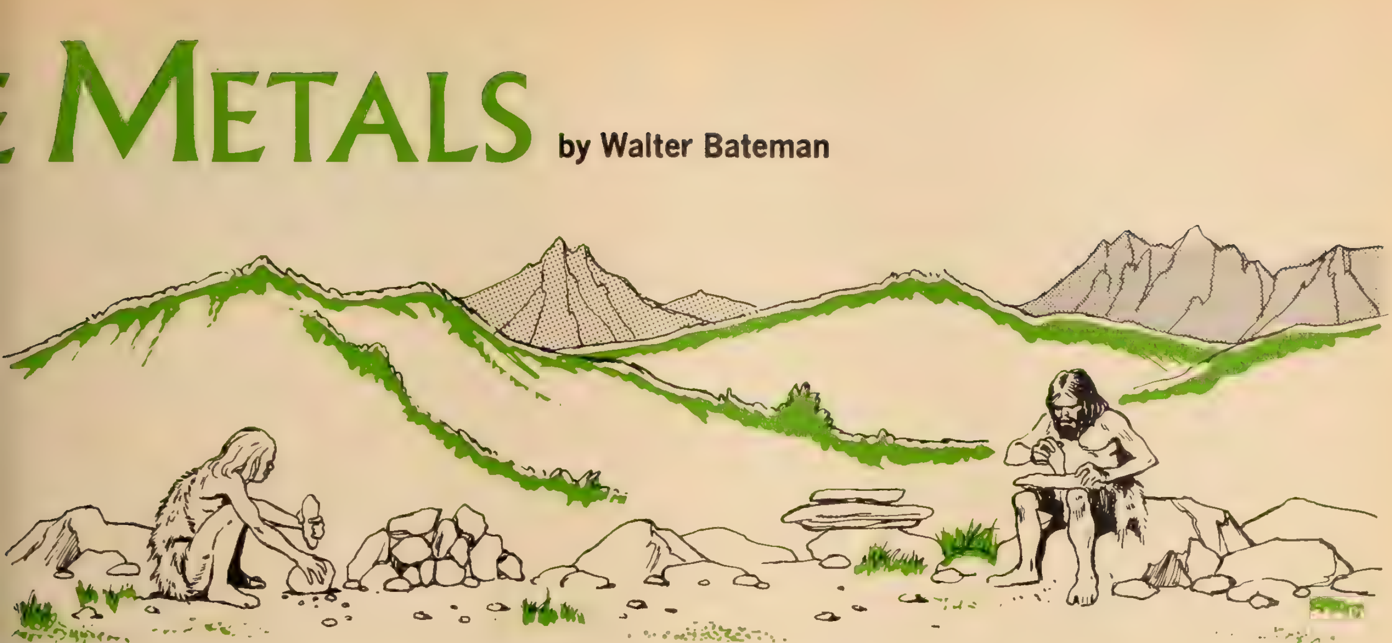
Archeologists think that the first copper ore may have been smelted in a Halafian village in what is now Iraq, about 4000 B.C. The people there had already invented a furnace with an oven, called a *kiln*, in which containers shaped of clay were baked to make them hard.

Inside a kiln the temperature rises high enough to smelt copper ore. The lucky accident may have happened in a kiln where some potter was experimenting with colored earth to paint his pots. If he tried copper ore, the heat may have smelted the ore into a lump of metal. The archeologists also found that the Halafians had melted copper and poured it into molds.

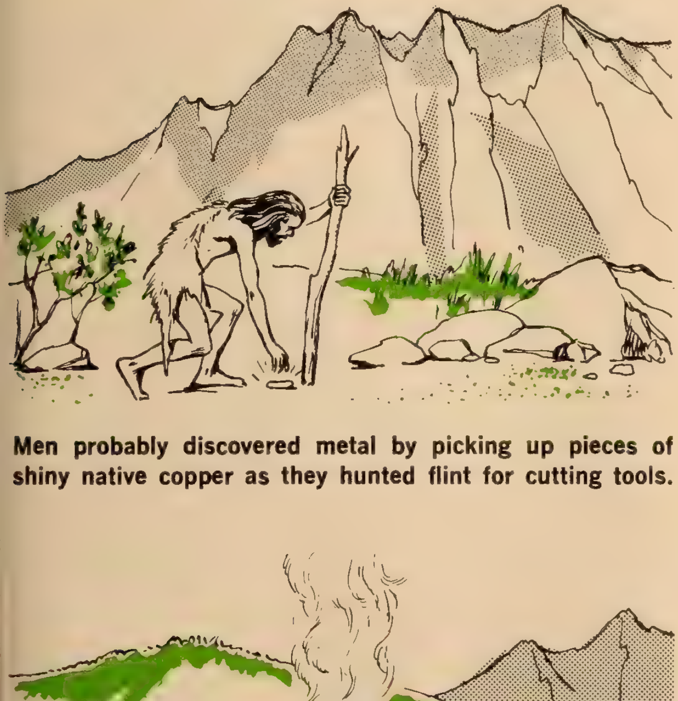
Walter Bateman is an Instructor in Anthropology and Chairman of the Division of Social Sciences at Rochester State Junior College, Rochester, Minnesota.

METALS

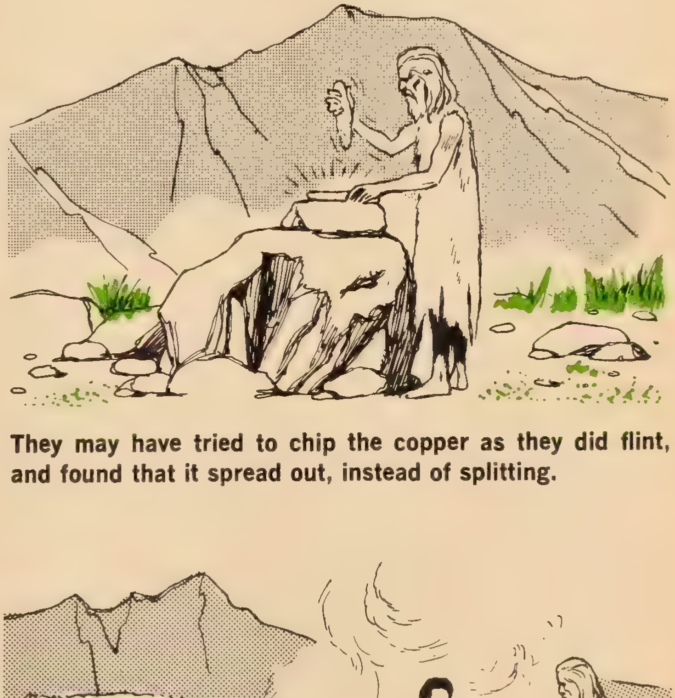
by Walter Bateman



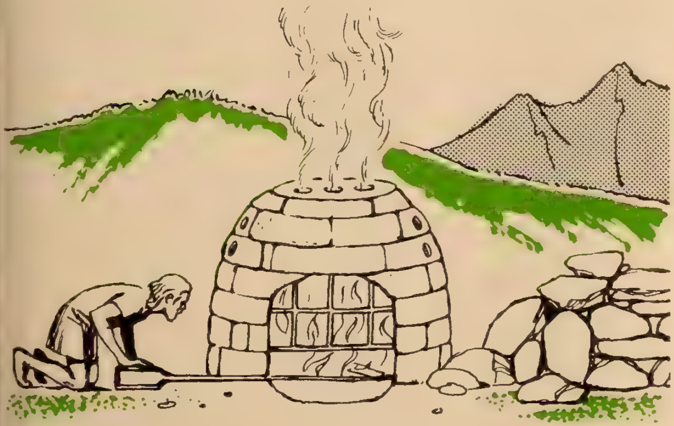
In the Stone Age, before people knew about metal, they cut things with flint, a kind of quartz that has sharp edges when split. They became quite skillful at chipping and flaking flint to make knives, axes, scrapers, and drills.



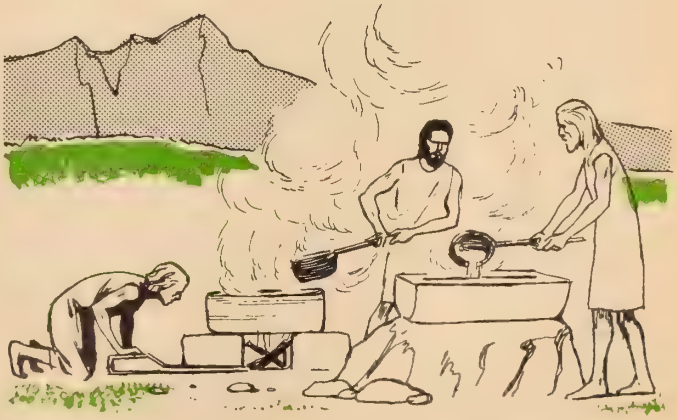
Men probably discovered metal by picking up pieces of shiny native copper as they hunted flint for cutting tools.



They may have tried to chip the copper as they did flint, and found that it spread out, instead of splitting.



Copper may first have been separated from an ore in a kiln like this, used 6,000 years ago to bake pottery. Air flowing through holes in the sides produced high temperatures.



Air blown into a fire with a crude bellows produced enough heat to melt native copper so that it could be cast, or poured into molds, to make ornaments of different shapes.

(Continued on the next page)

At first copper was too rare to be used much except for ornaments. Also it was too soft for good tools until someone made another lucky discovery, around 3000 B.C. In Sumeria, at the southeastern end of the Fertile Crescent, someone found that certain copper ores made a hard metal. By accident the Sumerians had smelted ores that held both copper and tin. The tin mixed with the copper to form an *alloy,* or mixture of metals, called bronze. Bronze is tough and hard; bronze knives stayed sharp. The Sumerians got their ore way to the south, in what is now Arabia, near a mining town called Oman. The ores from Oman are still a mix of copper and tin ores as they were in 3000 B.C.

Bronze weapons quickly became valuable. Kings wanted them for their armies. Rulers were willing to trade for copper and tin ores. Some found it necessary to fight for the ores. Both trade and war became important.

King Solomon's Copper Mines

Dr. Nelson Glueck, an American archeologist, read in the Bible that King Solomon had built a town called Ezion-geber "beside Eloth, on the shores of the Red Sea, in the land of Edom" (I Kings 9:26). Dr. Glueck went to the shore of the Red Sea by Eloth and poked around until he saw a mound that looked promising. He had his men start digging. Soon they uncovered a huge furnace built for smelting copper at the orders of King Solomon.

Dr. Glueck's workers were annoyed by the strong wind that blew sand in their faces all the time. They said that it was a stupid place to have built a town. But the ancient engineers who planned that ancient smelter must have been as wise as old King Solomon himself. They had used the wind to blow the furnace fires hotter. In the walls Dr. Glueck found holes, cleverly designed to let the wind blow in, to pass over the fire, to get heated, and then to blow into another furnace to make the next fire even hotter. It takes a hot fire to smelt copper ore.

Ezion-geber was also a seaport for trade. Here Solomon traded some copper for jewels and spices from Africa and Arabia. And to protect his trade and his mines and his smelter, Solomon built rock forts which Dr. Glueck also found. You can see how the use of metals increased both war and trade.

Trade meant travel. And travel meant that men would exchange ideas and think up more inventions: wheeled chariots, wagons, ships with sails, weights, measures, writing, coins. All sorts of new inventions came out of the cities built in the early years of man's use of metal.

After millions of years of hunting and after thousands of years of farming, men had left the Age of Stone and had entered the Age of Metal ■

HOW IT WORKS

Television

■ Suppose a machine gun is fired while being swung f
side to side. The bullets hit the ground in a line, kic
up dust which hangs in the air for a while. Inside
television set, a different kind of rapid-fire gun kick
puffs of light in a pattern of lines that makes the pic
you see. This gun shoots out *electrons,* tiny particles
are in all kinds of matter.

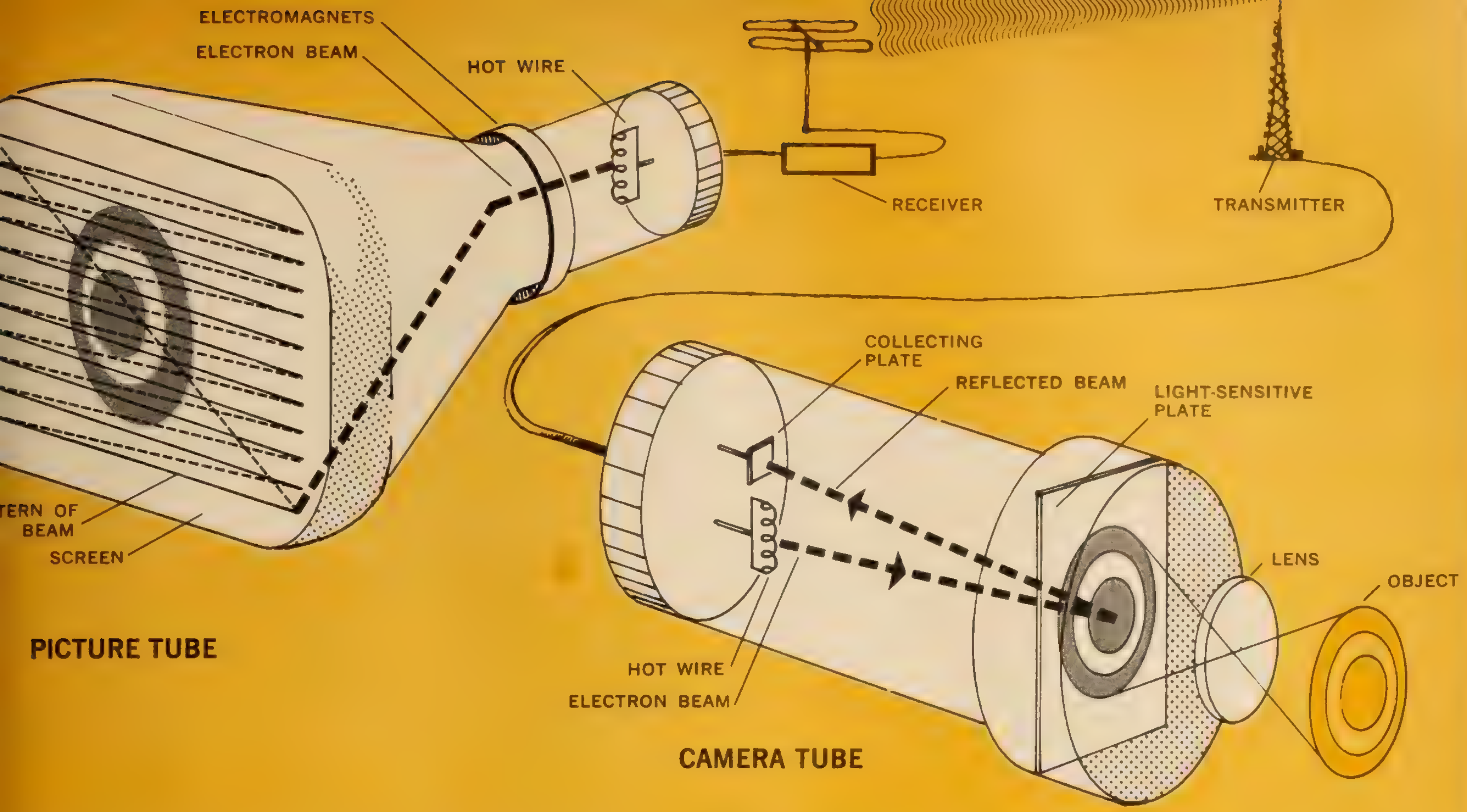
When you turn on a television set, a hot wire a
narrow end of the *picture tube (see Diagram 1)* s
shooting a fine stream of electrons at the *screen,* or f
of the tube. The inside of the screen is coated wi
substance called *phosphor* that glows when elect
strike it.

A stream of electrons is an electric current, an
electric current can be pulled by a magnet. There
electromagnets at the neck of the tube. The pull of
magnet keeps changing, so the electron beam is pu
in different directions. First it strikes the screen in
upper left corner *(see diagram),* then moves across
screen, leaving a line of light glowing wherever the
trons hit. From the right side of the tube the beam ju
back to the left side and traces another line just b
the first one. This keeps on until the beam reaches
bottom right corner of the screen, then it jumps bac
to the top left corner to repeat the same pattern. E
trip of the beam over the entire surface of the scree
called a *scan,* and each scan happens so fast that you
sees all the light on the screen at the same time.

When many electrons are flowing through the t
in a second, the spots where they hit the screen glow
brightly. Where the screen is dark, fewer or no elect
are hitting it.

Meanwhile, in the Television Studio . . .

The number of electrons being fired at any insta
controlled by signals from a television camera *(see
gram 2).* The light from an object in front of the ca
strikes a plate (instead of a photographic film) in
camera. This plate is *light-sensitive,* which means th


ELECTROMAGNETS
ELECTRON BEAM
HOT WIRE
RECEIVER
TRANSMITTER
TERN OF
BEAM
SCREEN
PICTURE TUBE
COLLECTING
PLATE
REFLECTED BEAM
LIGHT-SENSITIVE
PLATE
LENS
OBJECT
HOT WIRE
ELECTRON BEAM
CAMERA TUBE

t hits a spot on the plate, the light knocks electrons
of the plate at that spot. Where the light is bright,
ny electrons are knocked out of the plate; where it is
k, few or no electrons are knocked out.

rom the back of the *camera tube,* a hot wire shoots a
m of electrons that scans the plate. When the beam
kes a bright part of the plate (where light has knocked
ny electrons out), electrons in the beam enter the
e and stay there. But when the beam hits a dark spot,
electrons already in the plate push the electrons in
beam away from the plate. These beam electrons
el to a *collecting plate* which sends them out through
es as electric current. This changing current makes the
als that reach your television antenna and control the
of electrons in the picture tube of your set. Where
televised object is bright, your screen becomes bright;
re the object is dark, your screen is dark.

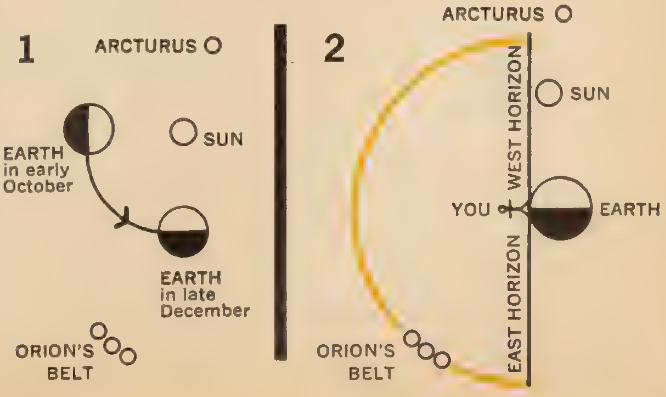
or TV

Vhite light and all other colors of light can be made
mixing red, green, and blue light in different ways.
olor television camera separates the light from the
ct into red, green, and blue light, and the camera
ls out a different set of signals for each of these colors.
n a color television receiver, the inside of the picture
screen is covered with tiny dots of three different
ls of phosphor. Some dots glow red, some blue, and
e green when they are struck by electrons. There are
e electron guns in the tube; one shoots electrons only
he dots that glow red, another at the dots that glow
n, and so on.

The dots of light are so tiny that your eye can only see groups of them. Where a group of red and green dots are glowing on the screen, you see a spot of yellow light. Where a group of dots of all three colors are glowing, you see a spot of white light.—Steven W. Morris

CAN YOU SEE ORION'S BELT AFTER DUSK IN LATE DECEMBER?

This question was asked in "Sky Watching at Midnight," in *Nature and Science* for October 3, 1966. In the three months since then, the earth has moved about 90 degrees in its orbit around the sun, while the direction of the stars from the sun has not changed (see *Diagram 1*). Diagram 2 shows that you can see Orion's Belt early in the evening at this time of year. Where would you look for it at midnight? Could you see it just before sunrise? When and where should you look for Arcturus?


1
ARCTURUS
SUN
EARTH
in early
October
EARTH
in late
December
ORION'S
BELT
2
ARCTURUS
SUN
WEST HORIZON
YOU
EARTH
EAST HORIZON
ORION'S
BELT

With some sand, some simple equipment, and a common Coleus plant, you can investigate . . .

GROWING PLANTS WITHOUT SEEDS

by Richard M. Klein

■ The only way to get a new plant is to plant a seed, right? Wrong. Some kinds of plants, such as ferns and molds, grow from *spores,* not seeds. And there are other ways of getting new plants—without using either seeds or spores.

One common way is called *rooting.* Not all plants can be used, but many house and garden plants can be multiplied in this way. Rooting has one important advantage to the grower—all of the plants you get will be exactly alike.

If you start plants such as Coleus *(see photo)* from seed, the new plants will show many different patterns of leaf color. This is because each seed has a combination of characteristics from its parents. If you root Coleus plants however, the plants will all be exactly alike. You can see the importance of this if you want to make "copies" of a plant. In many experiments it is important to have plants that are as much alike as possible.

A Bed for Plants

You can try to root some plants and see how this "copying" process works. First, make a "rooting bed" by punching a few holes in the bottom of an inexpensive plastic basin (one about eight inches deep and a foot wide is a good size). You can punch the holes with an ice pick or with a sharp nail. Then make the holes bigger by wiggling the ice pick or nail around in the hole. The holes will let excess water drain away so that the plants won't rot before they root.

You can use several different kinds of material to fill the rooting bed. One of the best is ordinary sand. Before putting the sand into the rooting bed, cover the drainage holes so that the sand won't leak out. To do this, put a piece of facial cleansing tissue over each hole. Then pour in the sand until it is about two or three inches below the rim of the plastic basin. Now, wash the sand to remove the dirt. Add about a pint of water and let the water trickle out of the basin (keep it in a sink so that you don't get water all over everything). If you can't get sand, use fine cinders, small gravel, Vermiculite, or Perlite (the last two are available from garden stores).

The only other piece of equipment you will need is a piece of clear plastic sheeting big enough to cover the top of the rooting bed. You might use the plastic bags in which clothing is returned from the dry cleaner, or the plastic bags in which food is packaged. Use a few wire hangers to keep the plastic from touching the plants in the rooting bed *(see Diagram 1).*

Some plants are very easy to root and it's best to start with them first. Later you can experiment with other kinds. You can get a Coleus plant from a florist's shop or even from a dime store. Then take a sharp knife or a single-edged razor blade and cut off the stem about two or three inches above the soil in the pot. (Don't throw away the pot and the "old" plant; continue to water it every other day.)

Trim off the lower leaves of the stem—they usually die anyway—so that the plant will not lose too much water. Your plant should look like Diagram 2. Now, simply stick the plant, stem end down, into the sand. Cover the top of the rooting bed with the plastic and keep the root-

Dr. Richard M. Klein is Caspary Curator of Plant Physiology at the New York Botanical Garden.

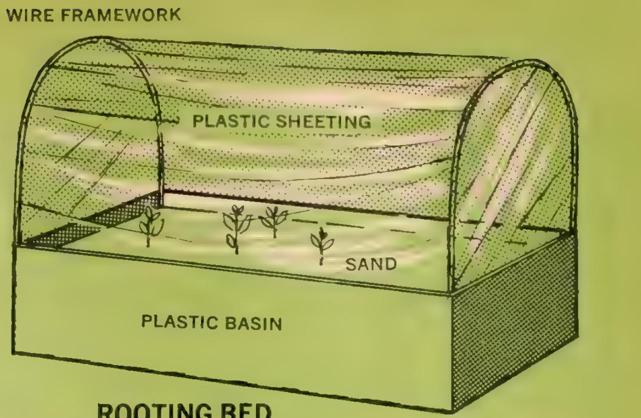
ing bed in a place where it will get some light but not direct sunlight. Be careful not to let the sand dry out. Every third day, carefully lift the plastic cover and feel the sand. If it is still damp, do not add water. If it is dry, add a cup of water.

In about two weeks, take off the plastic top and gently tug on the plant to see if it seems to be held in the sand. If it comes free easily, do not take it out, but wait another week. If the plant seems to be held firmly in the sand, carefully dig around the plant with a pencil or a table knife and lift it out. You will see that it has many roots on the bottom end of the stem. You can now plant this rooted Coleus in a pot of soil.

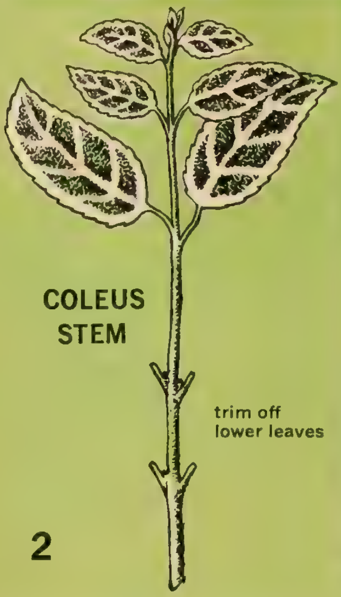
Now, look at the stump of the plant that you left in its pot. Buds will be growing on the stump. If you keep watering this plant, the buds will form stems. Then these can be cut off and rooted. In this way you can increase your supply of Coleus plants every few weeks. All of them will be exactly alike.

You can grow new ivys, philodendrons, chrysanthemums, and many other plants in the same way. Other plants, such as African violets, can also be grown this way, except that you don't even need to use the stem. You can simply cut off a leaf and put the leaf stalk *(petiole)* in the moist sand. New begonias and geraniums can be grown by rooting either the stem or leaf. You will find that some plants, like Coleus, will form roots within a week or 10 days. Others, such as philodendron, may take several weeks or even a month ■

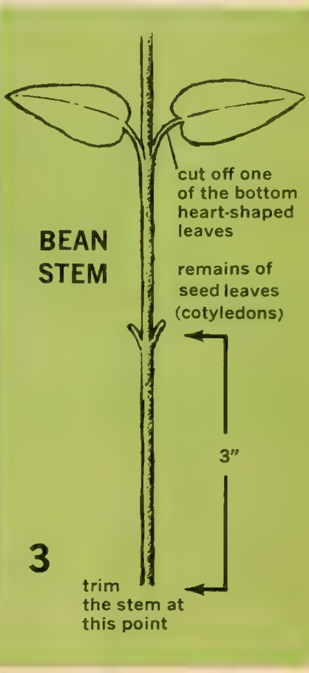
1



ROOTING BED



2


BEAN STEM
cut off one of the bottom heart-shaped leaves
remains of seed leaves (cotyledons)
3"
trim the stem at this point

3

INVESTIGATIONS

● You can buy a powdery material called Rootone from a florist's shop. It speeds up the rooting of some plants but slows down others. You can experiment with several different kinds of plants to see how Rootone affects them. Dip the cut end of the stem or petiole in the powder, shake off the excess, and put the cutting in the rooting bed. At the same time, put another cutting of the same kind of plant in the rooting bed. This is a "control" on your experiment, enabling you to compare the growth of a cutting treated with Rootone with a non-treated one.

● How does temperature affect the rooting time of plants? To test low temperatures, put the stems (in their rooting bed) in a refrigerator for a few hours a day; for high temperatures, set another rooting bed near a radiator. Stick a thermometer in the sand to find out the temperature near the bottom of the stems. How does the rooting time of these stems compare with that of stems of the same kind that are left at room temperature?

● Try rooting plants in water. This will allow you to add different chemicals to the water to see how they affect rooting. Besides Coleus and other house plants, you might try rooting bean plants in water. Soak some kidney bean seeds in water for six to eight hours and then plant them in soil. Let the seeds sprout and the plants grow for 10 days to two weeks. Then cut off the plants at the soil line and trim them as shown in Diagram 3. To reduce water loss, cut off one of the heart-shaped leaves.

To test the effect of different substances on rooting, get several pint containers, fill them with water, and set five bean stems in each. Then add different substances to the water. You might try salt, sugar, or aspirin. Be sure to try boric acid (available from drug stores). Dissolve a quarter-teaspoon of boric acid in a quart of water, then put one teaspoon of this solution into the pint of water with its five bean stems. Does the boric acid speed up or slow down rooting? What about aspirin, sugar, salt, or Rootone mixed with the water?

brain boosters

prepared by
DAVID WEBSTER

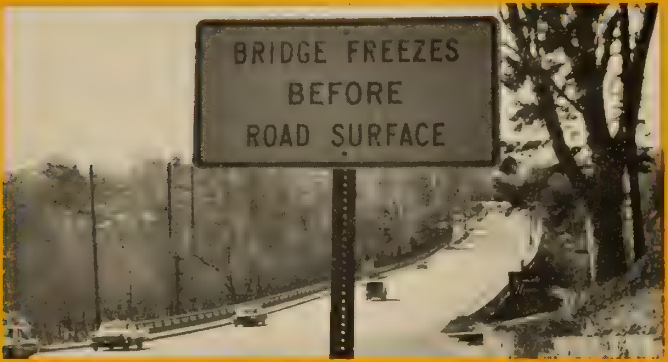
CAN YOU DO IT?

Can you get the inside of an egg out of the eggshell without cracking the shell?

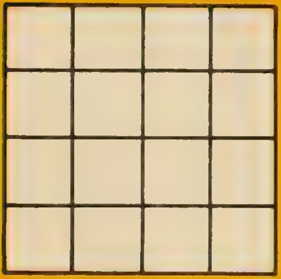
Submitted by Cheryl Anderson, Noxon, Montana

FOR SCIENCE EXPERTS ONLY

What happens to the weight of a metal tank as helium gas is pumped in? Does the tank's weight increase, decrease, or stay the same?



MYSTERY PHOTO Why does the surface of the bridge freeze before the rest of the road?

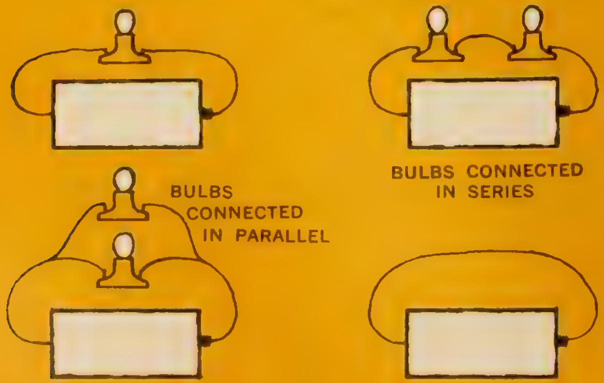


FUN WITH NUMBERS AND SHAPES

How many squares and other rectangles are there?

WHAT WILL HAPPEN IF . . . ?

Which battery will last longest?



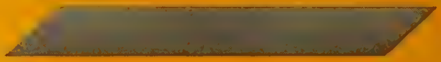
ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: A light bulb is almost empty inside except for a little argon gas and nitrogen gas. When a hole is made in a bulb underwater, the water will fill up most of the empty space. The little bubble left is the argon and nitrogen gas.

Can You Do It? One way to make a ruler balance with one penny is to put the penny on the ruler above the pencil. Can you find another way?

What Will Happen If . . . ? When a heated bottle is turned upside down into a pan of water, water will rise part way up inside the bottle.

Fun With Numbers and Shapes: The drawing shows the shape of an unrolled cardboard tube. Would an unrolled paper straw be the same shape?



For Science Experts Only: Ink is absorbed into the paper and cannot be erased unless some of the paper is removed. A pencil line can be erased, however, since it is only a thin layer of graphite on the paper's surface.

An Answer for Mr. Flicka

Here is how the photograph in the October 31 issue showing a circular pattern of white streaks was taken. A camera was placed on a tripod and aimed at the North Star. The shutter was left open for an hour or so. The streaks of light show how the stars *seemed* to move as the camera turned with the earth.

Can you figure out, by measuring the length of a single streak and how far it is from the center of the pattern, about how much longer than one hour the shutter was left open to take the picture? (Hint: If the shutter had been left open for 24 hours and the stars had been visible all that time, the streaks of light would be complete circles.)

Using This Issue...

(continued from page 2T)

kinds and areas rub against each other, your pupils are likely to think of friction primarily as something "bad," because it "wastes" so much energy. To help them realize the useful aspects of friction, have your pupils list as many devices as they can think of that would *not* work if there were no friction.

Just about everything that moves, from simple saws and pencils to animals, automobiles, elevators, and other machines, depends on friction to work at all. Without it, saws would not cut, pencils would not write, animals could not walk, belts and wheels would not turn each other, and turning wheels would not move over the ground. The simple act of picking something up with your fingers would be difficult, if not impossible.

Have your pupils try to think what would happen if they woke up some morning and found that friction no longer existed.

(The author of this article is now working on a unit on friction for the Elementary Science Study project of Educational Services Incorporated.)

Growing Plants without Seeds

This SCIENCE WORKSHOP written by Dr. Richard M. Klein of the New York Botanical Garden is a departure from the usual "seed-based" botany investigations in classrooms. You might discuss with the class why scientists like to have plants as much alike as possible for use in experiments.

In an experiment designed to test the effects of a certain chemical on plant growth, for example, the genetic makeup of the different plants might affect the results. This variable would be eliminated if all of the plants had the same genetic makeup, as is the case with plants all rooted from a common parent.

Botanists have learned a number of things about what affects the ability of plants to form roots. Light and both high and low temperatures slow down root formation. For some unknown reason, boric acid is a powerful stimulant of root formation. Rootone usually speeds up rooting but slows rooting in a few species. The active ingredient in Rootone, by the way, is *auxin,* a plant growth hormone (*see "How Does Light Bend Plants?",* N&S, *Jan. 10, 1966).*

Teaching Science...

(continued from page 1T)

A. Let's challenge all students. Let's give them all opportunities to search out meanings—concepts—through a groundwork of investigation. There are what I would call apprentice investigations which can serve as common ground for all. All the children do arrive at some kind of systematic assertion; however, the more able students make more sophisticated statements. Once the apprentice investigation has been done, additional investigations can be done on different levels.

Q. In a word, if it can be summed up in a word, what is the role of the teacher in the new approach to science in the elementary grades?

A. The role of the teacher is to create situations wherein the child discovers the structure of the real world. The teacher's role should be one of guide rather than guardian of the archives. Teachers uncover a text or course. They don't cover it; they make the classroom a place where children (in Bridgman's terms) "do their damndest with their minds, no holds barred." Children should not be robbed of the right to discover for themselves the relationship of thought and imagination to the "real" world. And a good deal of understanding of this world is based on experience.

Q. Is it possible for elementary school teachers to teach a modern science course without additional specialized training?

A. Permit me to restate your question. How can elementary school teachers, already overburdened, teach science?

First, as a school system develops its programs, rich in-service programs are necessary. Second, the use of high school and university consultants is not out of the question. But it is most important to realize that it takes time to develop the arsenal of facilities, equipment, and books to make science meaningful, just as it has taken time to make other programs meaningful. In good time, elementary school teachers will make the art of teaching science theirs. We must, however, not confuse methods of instruction with the materials of instruction.

Q. You seem to distinguish the words "investigation" and "experiment." Is there a distinction?

A. It seems to me there is. There are many ways of investigating—the library, the field, the discussion, the laboratory are all roads to investigation. Observation in the field may not be experimentation. Not all work in the laboratory is experimentation. An experiment is one tactic of the "art of investigation."

Q. Then you see science as more than process? Would you elaborate on this?

A. Science is part of a child's equipment in a modern world. Science gives him the tools he needs to explore the material universe, to seek orderly explanations (conceptual relationships) of objects and events, to test through investigation (through design of his own experimental procedures) his understanding of the way the world works.

Q. I take it that science reading skills should be part of a modern elementary school science program?

A. Definitely. As a child investigates he should develop such skills as locating information; reading diagrams; reading for the main idea and summarizing; reading for specific details; and organizing ideas in reports.

Q. Doesn't the provision for laboratory work at the elementary school level impose on the teacher a formidable task of collecting and preparing materials for pupil use in investigation?

A. Perhaps. Yet the center of good science instruction is investigation. Some of the materials required are readily available from convenient sources—even the dime store. Prepared laboratory materials are available from several commercial sources.

Q. If you had to do so, how would you define science teaching?

A. Science teaching must serve a general theory of teaching. In any specified art of teaching, a new environment is created; in responding to the changed environment, a learner gains capacities not achieved through prior experience.

It seems to me that in teaching science, a teacher should create an environment in which children explore the material universe and seek orderly explanations of the objects and events they uncover. But these explanations must be testable. In testing the orderly explanations they have fashioned, children use the processes of investigation — observing, analyzing, synthesizing, hypothesizing, reading, recording, discussing, experimenting, imagining, inventing—and the like. Thus, ordered explanations—concepts—come out of the investigation ■

(N&S *articles about approaches to science teaching are not meant to imply endorsement of any particular approach by The American Museum of Natural History.)*

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HEALTH AND DISEASE

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■ We all use the words "disease" and "health" easily—and know what we mean. But as words, they are not easy to define. Dictionaries are apt to note that disease is a departure from a state of health and that health is the absence of disease—which makes a nice circle.

"Health" and "disease," like "hot" and "cold" or "good" and "bad," are *polar* words—the members of a pair whose components depend on each other for meaning. But when we try to give such words precise meanings, we have to turn to some outside standard.

With "hot" and "cold," we have the freezing and boiling points of water as references, and we can measure the intensity of heat by the expansion of mercury or other substances. With "good" and "bad," we have codes of law and standards of conduct for determining the goodness or badness of any particular action. For health and disease, however, we have no universally accepted standard of measurement.

One proposal is to consider death as the complete absence of health; as long as there is any life, there is some health. But this does not provide meaning for absolute health, the complete absence of disease. Many of the words in common use are similarly difficult to define with scientific precision; yet they serve us well in communicating ideas. So we shall go on to discuss disease without making any further effort to define it.

The "Demon" Theory

Man has long been aware of disease and has speculated about its cause. It was an early and widespread idea that illness came from an evil spirit that had entered the body. Obviously, then, the cure was to get the spirit out, by either frightening it or coaxing it. This became the function of witch doctors, with their masks, rattles, and charms.

Even ancient peoples, however, did not rely entirely upon magic. It was all right for the witch doctor to call upon the toothache demon to depart; but in the meantime, a soothing application of coca leaves was not to be rejected. Thus, primitive tribes and peoples have discovered practical remedies for various kinds of illness. In fact, many of the drugs we use today have long histories extending far into the prescientific past. This is especially true of stimulants, pain relievers, laxatives, and the like.

The history of aspirin is a nice example. The pills we buy in the drugstore contain a man-made drug named acetylsalicylic acid. The origin of this drug stems from an extract of willow bark long used in folk medicine. The pain-relieving substance in the willow bark was synthesized by a German chemist in 1835 and named salicylic acid. Another German chemist later discovered that—for unknown reasons—the salicylic acid was more effective with the acetyl addition, and this product was marketed under the name "aspirin." But we still don't know much more than our ancestors did about how it works.

Much "folk medicine" was (and is) pure superstition—magic; and scientific studies have been needed to sort the sense from the nonsense. Today it is much more likely that our theories concerning the causes of disease will lead to improved treatments than it is that treatments will be im-

(Continued on page 3T)

nature and science
GESUNDHEIT!

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Man's Search for Good Health**
Knowing that disease can never be completely conquered, scientists are trying to improve man's environment to lessen sickness.

● **Men, Mosquitoes, and Malaria**
Man has tried to reduce malaria by attacking the disease carrier (mosquitoes) and the disease-causing organism. But both of these organisms have evolved forms that are resistant to chemicals and drugs.

● **How Diseases Get Around**
Diagrams show how some common infectious diseases reach our bodies, and what can be done to stop them.

The Most Common Disease
Scientists have discovered the cause of the common cold, but are only beginning to search for a way to make people immune to cold viruses.

● **Eat and Go Hungry**
An interview with a food scientist reveals the grim effects of a world shortage of protein foods and the efforts to find and develop new sources of nutritious food.

IN THE NEXT ISSUE

A biologist tells how he proved that owls rely on hearing alone to catch tiny mice in the dark . . . How different kinds of plants or animals live together in mutually beneficial relationships . . . SCIENCE WORKSHOPS: the heat to melt ice; plants and water.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Man's Search for Good Health

This article introduces some key ideas that are further developed in other articles in this special-topic issue:

- Seeking the total elimination of all disease is an unrealistic goal.
- Only a minority of the world's people have the degree of "good health" enjoyed by people in the United States.
- Disease is usually not caused by a single factor, such as a "bug," but may be the result of many factors in a person's environment.
- Disease-causing organisms are evolving forms that may become resistant to medicines that once were supposed to wipe out the disease entirely.

In addition to the background information given on these pages, you might want to dig deeper in these references:

- *Mirage of Health,* by Rene Dubos, Anchor Books, Doubleday & Company, Inc., New York, 1959, $1.25 (paper).
- *Health and Disease*, by Rene Dubos and Maya Pines, LIFE Science Library, Time Inc., New York, 1965, $3.95.
- *High School Biology, BSCS Green Version,* Rand McNally & Company, Chicago, Ill., 1963, $6.84. (Many other biology and general science texts have chapters on health and disease.)
- *The Viruses,* by Helena Curtis, Natural History Press, New York, 1965, $4.95 (paperback, $1.45).
- *The Hungry Planet,* by Georg Borgstrom, The Macmillan Company, New York, 1965, $7.95.

Men, Mosquitoes, and Malaria

Besides giving a picture of the widespread scientific efforts to reduce malaria, this article illustrates the concept that *all organisms are constantly adapting to changes in their environment.*

Topics for Class Discussion

- *Malaria parasites are transmitted to man by* Anopheles *mosquitoes. What other diseases reach humans by way of another animal?* Rabies reaches man via the bite of a dog or other mammal (including bats) that is in the final stages of this disease. In several other diseases, there is an *alternation of hosts*—the disease is passed from an animal to man, then back to an animal. Malaria is an example of this sort of cycle. Other examples include African sleeping sickness (which alternates between man or cattle and tsetse flies) and Rocky Mountain spotted fever (which alternates between man or rodents and ticks).
- *What are some different ways of reducing malaria disease?* The diagram "From Mosquito to Man" shows how malaria parasites are transmitted. One way of halting malaria is to reduce the number of *Anopheles* mosquitoes, either by killing them or destroying their breeding places. The other main barrier to malaria parasites is within the human body.

The article mentions several drugs that attack malaria parasites at various points in the body, and that have different effects. Atabrine, for example, keeps the parasites from developing fully, while chloroquine actually kills the parasites. Either way, if the male and female forms of the parasites can be kept from reaching mosquitoes (in which the parasites mate), the spread of the disease can be stopped.

- *What problems has man encountered in his attempts to wipe out malaria?* There are the usual problems of getting people to accept public health measures that are foreign to their culture. Mosquito control is often difficult and expensive. Also, the long-lasting chemical poisons such as DDT kill many other living things besides mosquitoes; the use of these chemicals is being curtailed. Finally, the use of poisons like DDT against mosquitoes and the use of drugs against malaria parasites has exerted a strong selective pressure on these organisms.

In the case of the malaria parasites, in some areas the non-resistant strains have been wiped out by steady use of drugs against them. This has speeded up the process of *natural selection,* encouraging the reproductive success of resistant strains of the parasite.

For more information on natural selection (including details about how mosquitoes become resistant to DDT), see the WALL CHART "How Is a Flower Like an Elk?" (N&S, *Nov. 14, 1966*) and "The Case of the Pale Sparrows" (N&S, *Dec. 5, 1966*), and the Teacher's Edition of both issues.

How Diseases Get Around

This WALL CHART shows how some common *infectious* diseases (spread by microorganisms) reach human beings, and how they can be stopped. Two of the diseases illustrated are also *contagious* (spread directly from man to man). Your pupils can probably recall instances when a cold or even measles was brought into a family or class by one member and then spread to others.

In discussing the ways in which different infectious diseases are kept from spreading, point out the importance of *sanitation*—particularly water purification, waste disposal, and cleanliness of food handling.

In the 19th century, diseases were associated with filth, but were thought to arise from bad odors of the decaying wastes. So steps toward sanitation were begun even before "germs" in wastes were recognized as the source

(Continued on page 3T)

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nature and science

VOL. 4 NO. 8 / JANUARY 9, 1967

SPECIAL-TOPIC ISSUE

DISEASES AND WHAT WE CAN DO ABOUT THEM

GESUNDHEIT!

What have scientists discovered about the common cold? To find out, see page 10

nature and science

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Man's Search for Good Health

**Man once thought he could "defeat" diseas
But scientists now know that disease can nev
be completely conquered, and they think th
it is foolish to try for a final victory.**

■ Have you ever wished you were born in the early ye
of the United States, in the days of Crockett, Boone, a
Bowie? Those were exciting times, rivaling today's age
rockets, Batman, and the Beatles. But before you w
yourself back to the early 19th century, consider this: O
half of the children born then lived to be five years o
The other half died of such diseases as smallpox, sca
fever, and typhoid.

Today, 97 out of 100 babies born in the United Sta
live to be adults. One after another, nearly every seri
childhood disease has been brought under control. Wi
spread outbreaks of disease, or *epidemics,* are now r
in the United States. Both men and women can expect
live into their seventies. Facts like these make it seem t
disease is well on the way to defeat in the United States

But wait a minute. Look at some other facts. Even w
added bed space, hospitals are as crowded today as t
ever were. Diseases still affect the same percentage of
population as they did 50 years ago (although they
fewer people). Since most childhood diseases can now
avoided, many people live long enough to suffer from
diseases that strike most often in middle age—cancer, ar
ritis, diabetes, heart disease.

Throughout history, humans have dreamed of a life ithout disease. In the past 100 years, as scientists learned ore about the causes of diseases and as new "miracle" ugs were made, people began to look forward to the lefeat" of disease. But disease is far from conquered and ere is little chance that it ever will be.

"Good health" is a hard term to define, but the health a group of people is usually measured by how many of em survive childhood and how long they live. By these easures, only a few countries in the world have healthy pulations. They include the United States, Canada, ngland, the Soviet Union, and most European countries.

In the rest of the world—where two-thirds of the earth's ople live—the picture of health is quite different. In dia, only one of three people born today can expect to e to the age of 50. As recently as 1958, a malaria epi-mic swept through Ethiopia, killing 150,000 people. nd in many African and Asian countries, those boys and rls who survive the many childhood diseases still face a im life without enough of the right kinds of food (*see e article, "Eat and Go Hungry"*).

Only a great deal of work, money, and time will bring ood health" to all of the world's peoples. In the mean-ne, scientists are looking again at the idea of "defeating" sease. They not only doubt if it is possible, but they onder if it is wise to try.

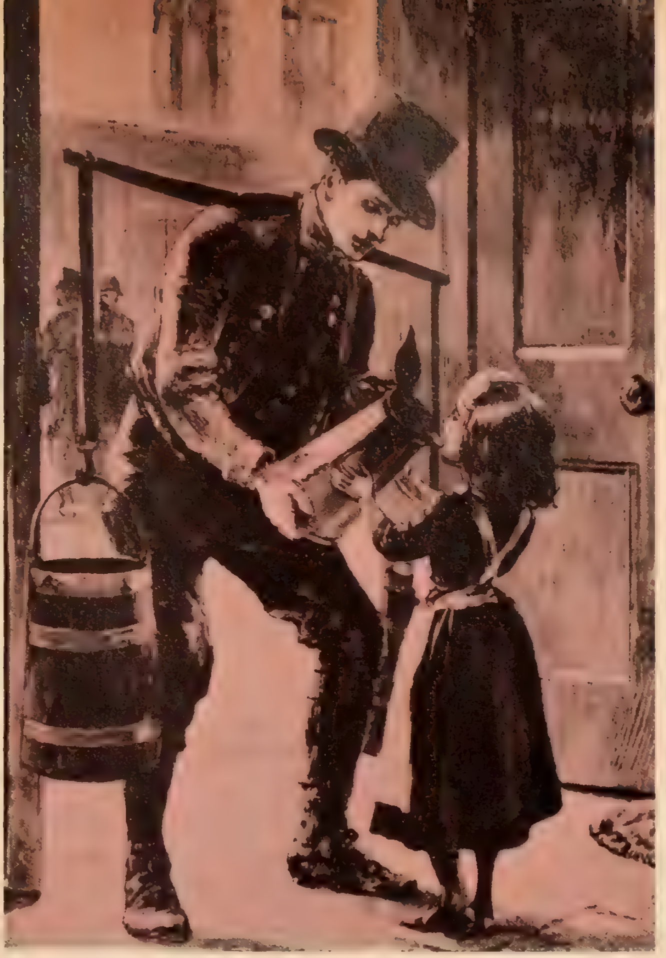
urrounded by Disease

All living things have diseases, including trees, the grass a lawn, your pet dog or cat. Even the bacteria that fect animals and plants often have their own diseases.

Among humans, it is a popular idea to blame most ill-ss on "bugs" or "germs." But few diseases have just e cause. Many people carry disease-causing "germs" in eir bodies. This alone doesn't make them sick. Some-ing else in their surroundings, or *environment*—such as e weather, the food the people eat, or even a family arrel—may help the disease flare up. Illness usually has variety of causes, not just one.

Thus, a person's environment has a great deal to do ith his health. The disease *tuberculosis*, for example, ten strikes where people are crowded together, whether a village hut in India or in an apartment in an American ty. Also, in some parts of the United States, people now e in an environment that includes air pollution and a st pace of life. These conditions have helped cause an crease in diseases of the lungs and heart.

Scientists now know that simply finding new drugs and edicines to fight disease are not enough. In some cases, w kinds of "germs" have appeared that are able to resist e drugs that used to be able to kill them (*see the article "Men, Mosquitoes, and Malaria*). Scientists expect the same thing to happen with other kinds of disease germs. We can still hope to reduce sickness by using what we already know about diseases and by learning more about how disease works in man's environment ■



This girl got a drink—and perhaps a deadly disease—from the pitcher of a public water carrier of about 200 years ago. At that time, people had no idea of how diseases could spread from person to person.

■ For more information about diseases, how they spread, and how they can be controlled, look for these books in your library or bookstore: **Health and Disease,** by Rene Dubos and Maya Pines, LIFE Science Library, Time Inc., New York, 1965, $3.95; **The Wonderful World of Medicine,** by Ritchie Calder, Garden City Books, New York, 1958, $2.95; **Modern Medical Discoveries,** by Irmengarde Eberle, Thomas Y. Crowell Co., New York, 1959, $3.

Diseases and What We Can Do About Them

This special-topic issue was prepared with the advice of Dr. Edwin D. Kilbourne, who is Professor of Public Health and Director of Virus Research at the Cornell University Medical College in New York City. Editor of the issue for *Nature and Science* was Laurence P. Pringle.

Humans once thought they could wipe out this dread disease. Now they wonder if they will ever completely break the deadly cycle of . . .

men, mosquitoes

■ About a year ago, high fevers and shaking chills downed hundreds of United States troops in Vietnam. Army doctors knew right away what the trouble was—*malaria*. But strangely, some of the most powerful drugs were useless against the disease. In three months, 1,801 servicemen caught malaria and 12 died of it. More hospital beds were filled with malaria patients than with those wounded by enemy action.

To the folks back home, the news came as a surprise. After all, malaria was wiped out in the United States years ago. Most Americans tend to think of it as one of the world's solved problems.

They couldn't be more wrong. Malaria is still the world's number one health problem. The World Health Organization estimates that it strikes 150 million persons a year, killing at least a million and disabling the rest.

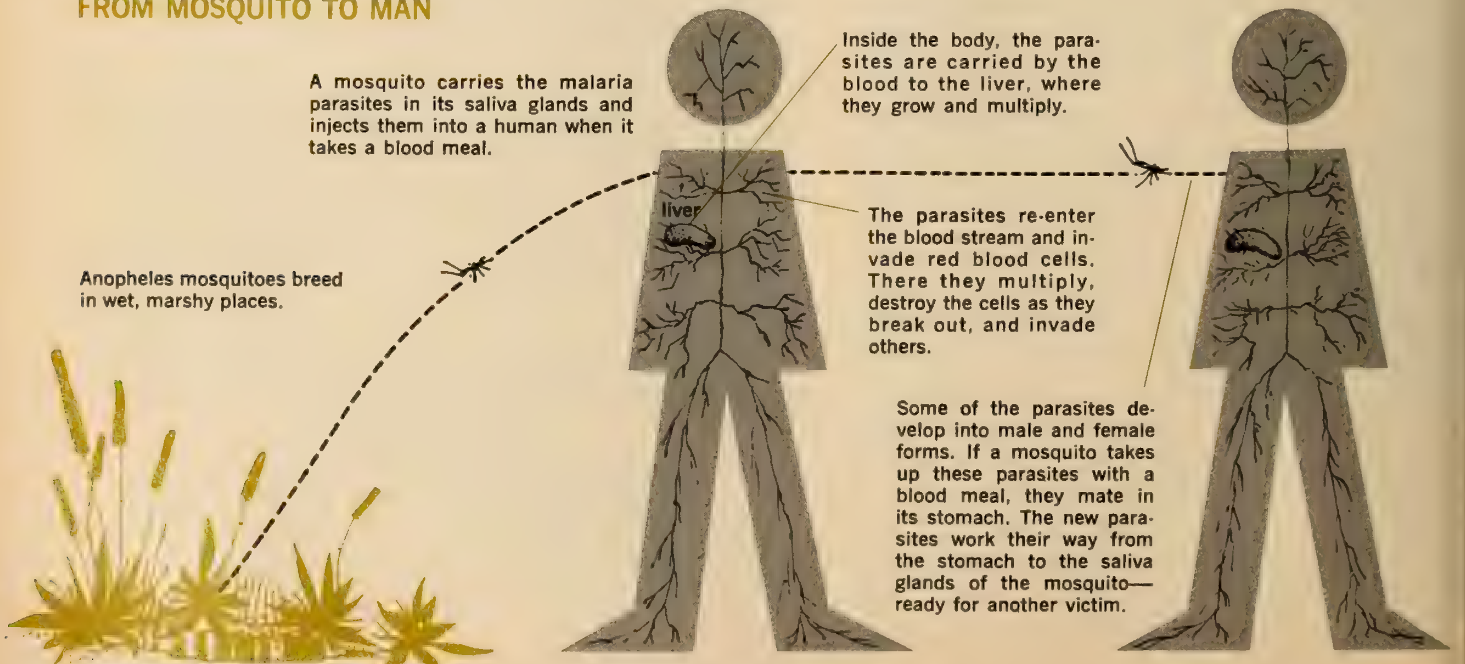
Malaria has been a major health problem since ancient times. It existed long before it was named. The earliest written records from Assyria, Egypt, and China tell about a disease that was clearly malaria. Later, when the disease was thought to be caused by poisonous vapors from marshes, it was named after the Italian words *mala* and *aria,* meaning "bad air."

Adapted from an article in the September 25, 1966 issue of The New York Times Magazine © *1966 by the New York Times Company. Reprinted by permission.*

From Mosquito to Man

Still later, the true link between marshes and malaria became known. Marshes are a breeding area for mosquitoes. Malaria is carried from one person to another by *Anopheles* mosquitoes. Since the male mosquitoes don't bite, only the females spread the disease. An infected mosquito lands on a person and shoves her needle-like *proboscis* through the skin. But before she begins her meal of blood, she injects a substance that keeps the blood from clotting.

FROM MOSQUITO TO MAN



A mosquito carries the malaria parasites in its saliva glands and injects them into a human when it takes a blood meal.

Inside the body, the parasites are carried by the blood to the liver, where they grow and multiply.

Anopheles mosquitoes breed in wet, marshy places.

The parasites re-enter the blood stream and invade red blood cells. There they multiply, destroy the cells as they break out, and invade others.

Some of the parasites develop into male and female forms. If a mosquito takes up these parasites with a blood meal, they mate in its stomach. The new parasites work their way from the stomach to the saliva glands of the mosquito—ready for another victim.

and malaria

by C. P. Gilmore

Along with this substance, she injects the organisms that cause malaria. These are one-celled *parasites* too small to be seen except with a microscope. (A parasite is a plant or animal that lives on or in another organism.) The parasites lead a double life, part of it in mosquitoes and part in humans. And during their life cycle, they go through several changes of form *(see diagram on preceding page).*

Malaria parasites don't seem to make mosquitoes sick. But man isn't so fortunate. At one stage in their cycle, the malaria parasites invade the red blood cells of man. In a few days the cells break, releasing many more parasites. As the red cells burst, the cells are destroyed faster than the body can replace them. The victim suffers from high fever (often 104 or 105 degrees), chills, nausea, general aches and pains, and sometimes death.

The attack can last for weeks. Some patients don't regain their strength for months. And even then, the parasites may remain in the liver, causing attacks years later.

Search for Malaria Medicine

As has happened in the case of many diseases, man found a treatment for malaria before he had any idea of its cause. The treatment involved the bark of the cinchona tree, long used as a medicine by the Indians of Peru. In 1632, after the conquest of Peru, explorers took some of the bark back to Europe. Some 200 years later, the white, bitter crystals known as *quinine* were identified as the substance in the bark that made it a remedy for malaria.

But quinine has its drawbacks. It can cause dizziness, ringing of the ears, and partial deafness. And the tropical tree from which it comes may not be available in time of need. In World War II, in fact, the major supply was cut off when the Japanese captured Indonesia, the source of most of the world's quinine.

By the beginning of World War II, fortunately, several man-made malaria medicines had been discovered. *Atabrine* was the best. Men who took it regularly could be bitten by infected mosquitoes without becoming ill. The atabrine circulated in the blood stream, keeping the disease from developing.

To test anti-malaria drugs, Anopheles mosquitoes are allowed to bite humans who volunteer for these studies. Most of the volunteers are convicts in prisons.

Yet Atabrine's success was far from complete. Malaria was still the chief problem of military medicine throughout World War II. Half a million United States servicemen fell victim to the disease. In the South Pacific, it took five times as many men out of combat as did enemy action.

In an attempt to find better medicines, scientists in the United States and elsewhere began a massive search. They tested more than 18,000 drugs and found 80 that seemed to show promise. Then began the long, dangerous part of their research–testing the drugs on human volunteers, mostly prisoners.

One of these was *chloroquine,* the world's most effective malaria medicine for more than 15 years. The drug circulates in the blood and kills malaria parasites soon after they enter the red cells in the blood stream. Thus a man can be bitten by an infected mosquito and show no signs of malaria at all. Chloroquine was given to United States troops in Korea.

(Continued on the next page)

In this laboratory of the Public Health Service, rabbits and monkeys are used to test anti-malaria drugs. Thousands of malaria-carrying mosquitoes are also raised here.

Men, Mosquitoes, and Malaria (continued)

But as soon as men left Korea and returned to the United States, hundreds of them came down with malaria. It seems that, in Korea, the medicine had killed parasites in the blood but it didn't kill those that reached the liver. Thus, as soon as a soldier stopped taking chloroquine, the organisms surged into his blood.

So investigators came up with a drug called *primaquine* to kill the parasite in the liver. Soldiers returning from Korea took primaquine for 14 days during the trip home. The sudden outbreak of malaria in the United States stopped as though someone had turned off a faucet.

At War with Mosquitoes

The search for new drugs is only one way of reducing malaria. Another way is to stop the malaria parasites from even getting into the blood of humans. Shortly before World War II, the chemical poison DDT was discovered. This opened the possibility of killing the mosquitoes that carry malaria.

After a mosquito bites, she usually perches on a wall or ceiling while digesting her meal of blood. If the walls and ceilings are sprayed with DDT, the mosquito's feet will pick up a dose of poison that will kill her. DDT keeps its killing power for months. So if every home in an area can be sprayed several times a year, almost every infected mosquito will be killed before it can pass on an infection. In this way, wiping out malaria in entire regions suddenly seemed possible.

Shortly after World War II, a National Malaria Eradication Program was set up in the United States. By 1950, the disease—which only a few years earlier had been infecting thousands of Americans a year—was almost completely wiped out.

In 1955 the World Health Organization set a goal of ridding the world of malaria. In the 10 years following, the number of cases in the world has dropped from almost 250 million to about 150 million a year. Deaths from malaria, estimated at no fewer than two million a year, have been cut in half.

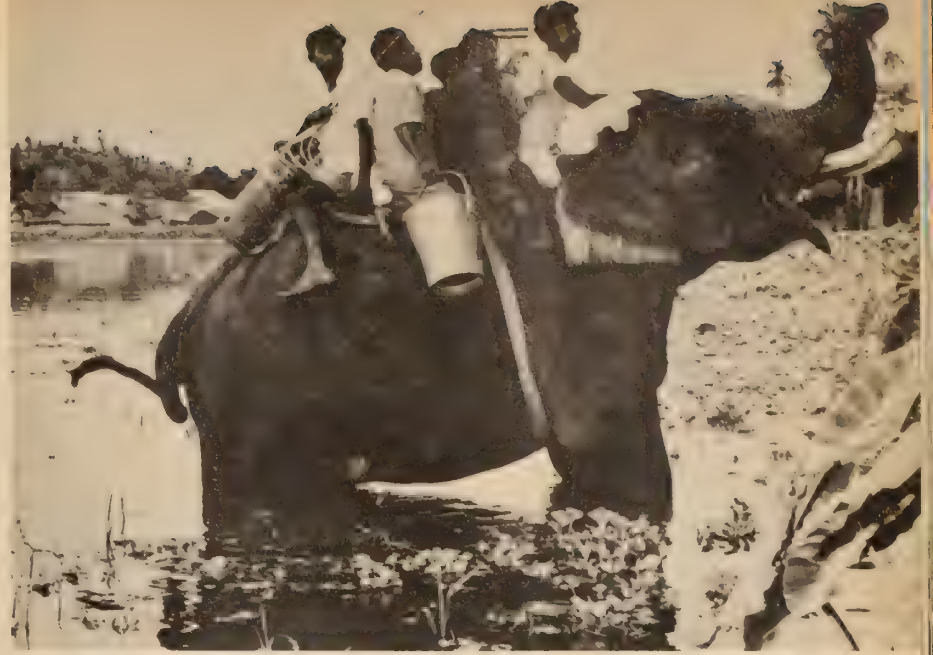
But serious problems stand in the way of the goal of the World Health Organization—to wipe out malaria all over the world. One such problem arose in 1951—four years before the W.H.O. program got started. In Greece, medical teams reported that some mosquitoes there weren't being killed by DDT. The insects were resistant to the poison. In anti-mosquito campaigns, most of the mosquitoes are quickly killed. Some, however, are able to survive. They live to breed and their young are also able to resist DDT. After a few years of DDT spraying, all of the mosquitoes that can't resist DDT have been killed. But a new population of DDT-resistant mosquitoes evolves *(see "How Is a Flower Like an Elk?",* N&S, *November 14, 1966).*

Mosquito resistance to DDT is a growing problem. About 60 kinds *(species)* of *Anopheles* mosquitoes spread most of the world's malaria. Of these, some 17 species are now resistant not only to DDT but also to most other widely-used insect poisons. Also, scientists are worried about the dangerous effects of DDT on other animal life. DDT used as an insect poison has killed many other animals and is considered by many scientists to be a threat to human health. This has made mosquito control teams more cautious about the widespread use of the chemical.

One Problem Leads to Another

The program has run into other snags, too. In some African and Asian countries, political unrest, wars, and revolts have made effective programs impossible. Some people resist the anti-malaria programs. And in some parts of the world, the wildness of the land makes it almost impossible to prevent malaria.

"All you have to do is fly over the Amazon basin or go



From the back of an elephant, an anti-malaria team in India sprays poison to kill mosquitoes. In many roadless areas of the world, mosquito control is almost impossible.

Insect poisons sprayed inside this home (left) in a Philippine village will help protect the family from malaria. In some parts of the world, however, mosquitoes have evolved that are not harmed by powerful insect poisons.

up the rivers of Surinam," says Dr. G. Robert Coatney, former chief of the National Institute of Allergy and Infectious Diseases. "How are you going to find the people to treat in such places? How are you going to eliminate malaria in people you can't even find?" And such untreated populations are reservoirs of infection that can break out into neighboring regions at any time.

Nor are these the only reservoirs. A few years ago, doctors discovered that man can get a type of malaria that is a disease of monkeys. This discovery dealt another blow to hopes of wiping out malaria throughout the world. It meant that even if the disease could be totally eliminated in man–doubtful, at best–reservoirs of infection might remain alive in monkey populations in the jungles of South America, Africa, and Asia.

But the crowning blow was yet to fall, and from another direction. In 1960, two men working for an oil company in South America showed up with malaria symptoms. The local doctor gave them the usual chloroquine, but it had no effect. A type of malaria parasites had evolved that could resist chloroquine. The parasites had become resistant to the medicine in the same way that mosquitoes had become resistant to DDT.

Later, chloroquine-resistant malaria showed up in Thailand, Malaya, and Cambodia. The chloroquine-resistant type of malaria was the one that hit American servicemen in Vietnam a year ago. Supplies of quinine–the old standby–were rushed to Vietnam to control the new outbreak of malaria. In addition, Army doctors tried a new drug called DDS (for diaminodiphenylsulfone).Daily doses cut the rate of new malaria cases in half.

DDS will help. So will the continuing anti-mosquito programs in Vietnam. But malaria is far from defeat. DDS doesn't stop all cases–only about half. And no one knows how long it will be before malaria parasites that are resistant to DDS will appear.

And so the search goes on–in Army research centers, in drug-company laboratories, and elsewhere–for new medicines useful against malaria. But scientists are not as optimistic as they once were.

"We thought we had malaria under control in World War II," says Col. William D. Tigertt, director of the Walter Reed Army Institute of Research. "But now, 20 years later, we still face the same problems."

Still, the 11-year efforts of the World Health Organization have cut the number of malaria cases in half. But many scientists now doubt that man can ever wipe out malaria completely. After all, the malaria parasites and the mosquitoes that carry them have been on the earth for thousands of years. Like all living things, they can become adapted–in this case, to drugs and DDT. They will not easily be conquered ■

HOW
GET

■ The "germs"
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the food we eat.
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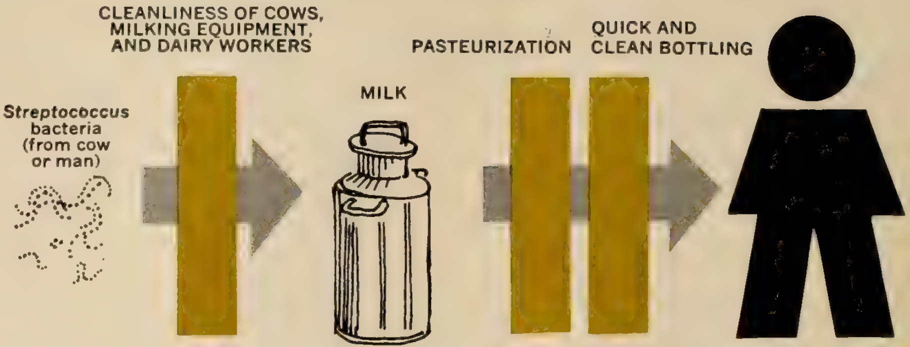
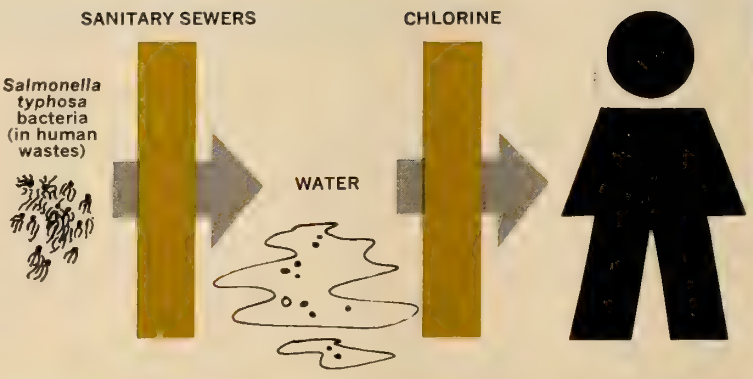
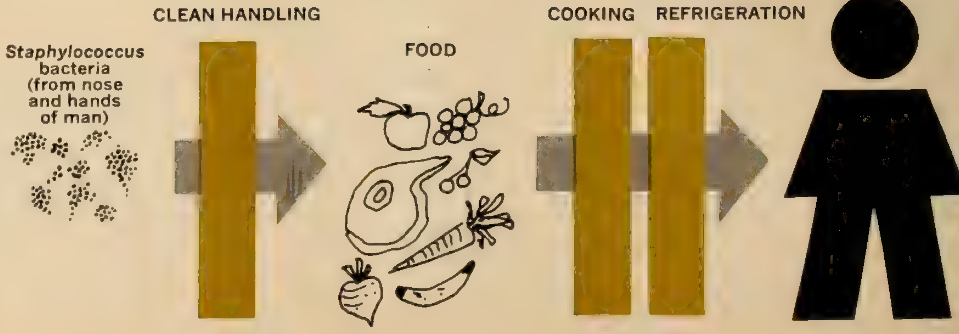
SPREAD BY MILK, strep throat is caused by a kind of bacteria called *Streptococcus*. The bacteria can be killed by heating the milk to about 140°F (*pasteurizing* the milk). Then the milk should be quickly—and cleanly—bottled to keep bacteria from re-infecting it.


Streptococcus bacteria (from cow or man)
CLEANLINESS OF COWS, MILKING EQUIPMENT, AND DAIRY WORKERS
MILK
PASTEURIZATION
QUICK AND CLEAN BOTTLING

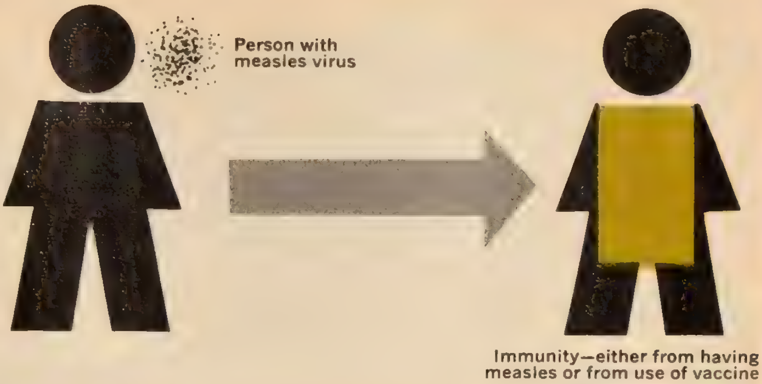
SPREAD BY WATER, the disease typhoid fever is caused by a kind of bacteria called *Salmonella typhosa*. These bacteria are found in human wastes, and typhoid is usually spread when human wastes get into water supplies. Sanitary sewers can help prevent this from happening, and adding chlorine to the water kills the bacteria.


Salmonella typhosa bacteria (in human wastes)
SANITARY SEWERS
WATER
CHLORINE

SPREAD BY FOOD, a kind of bacteria called *Staphylococcus* can cause food poisoning if it is allowed to grow in food and form a poison (*toxin*). To keep food free of bacteria, it should be handled as little as possible and handled only with clean hands. The heat of cooking kills the bacteria before they can form the toxin. Keeping food in a freezer or refrigerator stops the growth of bacteria that may get into the food after cooking.


Staphylococcus bacteria (from nose and hands of man)
CLEAN HANDLING
FOOD
COOKING
REFRIGERATION

READ BY THE AIR WE BREATHE, measles is a *conta-*
us disease, passed from one person to another by an
isible fine spray of virus particles. There is no good way
stop the spread of measles from one person to another.
e only practical way to keep people from getting measles
o make them immune to the disease. You can become
mune to measles for life by "catching" the disease or by
ng a *vaccine (see "How a Vaccine Works," below).*
ner way, your body's defenses are "armed" against any
ther measles virus that enters your body. Other vaccines
o protect us from smallpox, whooping cough, diphtheria,
l polio.


Person with measles virus
Immunity—either from having measles or from use of vaccine

SEASES
OUND

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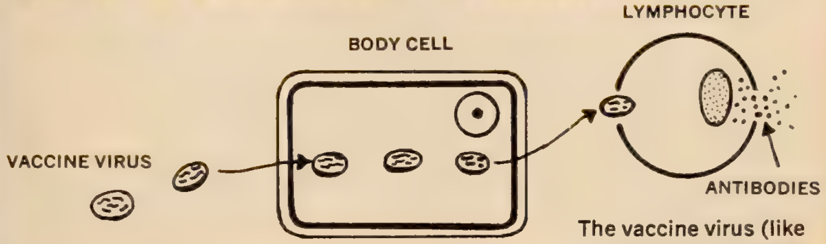
HOW A VACCINE "WORKS"

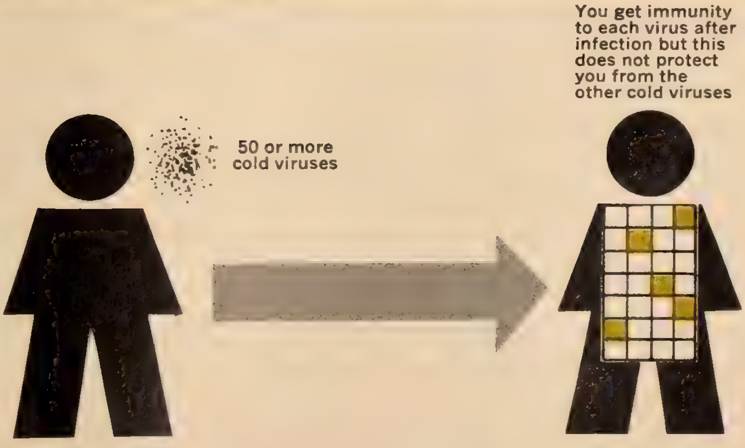

LYMPHOCYTE
BODY CELL
VACCINE VIRUS
ANTIBODIES

Measles virus is weakened, or "tamed," in the laboratory, then injected into humans.

This weakened vaccine virus is able to enter and grow in body cells but does not cause measles disease.

The vaccine virus (like a wild virus) causes cells called *lymphocytes* to produce *antibodies,* which remain in the blood stream, ready to destroy any measles virus.

ALSO SPREAD BY AIR, the common cold is caused by any one of at least 50 different kinds of virus. Once you have "caught" a cold from one virus, your body's defenses are able to fight off infection from that particular kind of virus for some time, perhaps for life. You can still be infected by other cold viruses however. Scientists are just beginning to search for vaccines to protect people from cold viruses.


You get immunity to each virus after infection but this does not protect you from the other cold viruses
50 or more cold viruses

The Most Common Disease

by Edwin D. Kilbourne

It isn't serious, but we all "catch" it again and again. Here is what scientists have discovered so far about the common cold.

■ Everybody knows about common colds because everybody has had them. Malaria and yellow fever are only strange names to most of us. We may know that they are diseases, but they happen to someone else, far away. Perhaps we don't think of the common cold as a disease. Sometimes we just call it a "runny nose" or a "sore throat." The stuffy nose may be bothersome for a few days, but it doesn't usually make us feel very sick and it may not even keep us from work or play.

But colds *are* diseases, and very important diseases, at that. Each year they affect the health and ability of hundreds of millions of people. Colds cause the loss of hundreds of millions of dollars in industry by keeping workers home or making them less able to carry out their work. And colds cause children to miss valuable time at school. Thus, the common cold is so important not because it is a *serious* disease but because it is so *common.*

What Causes Colds?

What do scientists know about the common cold? What is the cause? How is it spread? Is it "catching"? Does it come from being "cold" or "chilled"? And most important, can the common cold be cured? (Doctors have an old joke that if you treat a cold it will last seven days; if you don't treat it the patient will get better in a week!)

For many years it has been known that people have colds most often in the colder months of the year. Some scientists felt this proved that colds were, in fact, caused in some way by cold temperatures and chilling of the body. But other scientists pointed out that colds act like many other *contagious,* or "catching," diseases. Colds seemed to spread from one person to another in the same household. Colds also seem to occur in *epidemics*—that is, many people in the same place at the same time get colds. Scientists already had evidence that showed that colds were not caused by the kind of germs called *bacteria,* so they suspected that *viruses* might be the cause of colds. (Most viruses are smaller than bacteria and, unlike bacteria, viruses can reproduce only when they are in living cells.)

More than 50 years ago a scientist named Dr. W. von Kruse took some liquid, or *mucous,* from the nose of a man with a cold. Dr. Kruse then put the mucous through a filter that had holes small enough to stop bacteria from passing through. When he put the liquid that had passed through the filter into the nose of another healthy man, the man

Dr. Edwin D. Kilbourne is Professor of Public Health and Director of the Division of Virus Research at the Cornell University Medical College in New York City.

soon came down with a cold. Since the cause of the disease had passed through a filter, it must have been something smaller than bacteria. It was probably what was then called a "filterable virus."

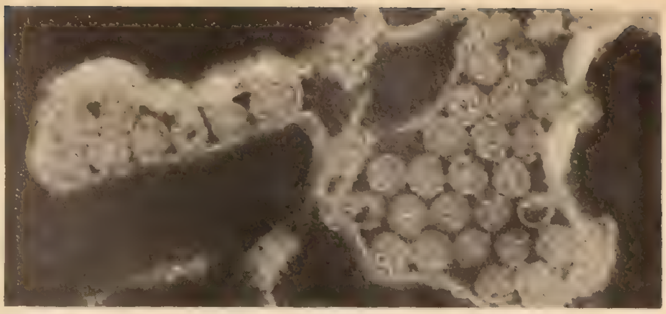
Gradually, scientists found more and more evidence that colds were contagious and probably were caused by viruses. A dramatic example of how colds spread is a story of the Arctic community of Spitsbergen. This group of islands, north of Norway, was isolated from the rest of the world by ice each year from October until the end of May. When the ice melted, a boat bearing mail and supplies was able to get through to the people of Spitsbergen.

During the long cold winters, the people were almost free from colds. But each spring, soon after the first boat docked, an epidemic of colds began and went on until almost all the people had had a cold. Apparently, someone on the incoming boat had a cold that quickly spread to the people in Spitsbergen. By being out of contact with the cold virus during their winter isolation, the people of Spitsbergen had apparently lost their resistance to the virus. Incidentally, during the coldest part of the year, they had no colds.

Discovery from an Accident

Only 10 years ago a great discovery was made that has answered many of our questions about colds. In a laboratory in Salisbury, England, scientists who had been studying colds for many years discovered how to grow a cold virus.

Viruses grow only in living cells. In order to study viruses, scientists prepare groups of cells from human or animal tissues. These cells are called *tissue cultures* or *cell cultures*. They are put into an *incubator*, where the temperature of the culture can be controlled. If viruses are put into these cultures, they can be detected because they usually grow in the cells and destroy or damage them. For years, mucous from people with colds had been put into such cultures, but no effect could be seen. The cells in the cultures looked healthy and unchanged.



This photograph of a fragment of a tissue culture shows several round polio virus particles in a human cell. The viruses that cause the common cold are related to polio viruses and look about the same.

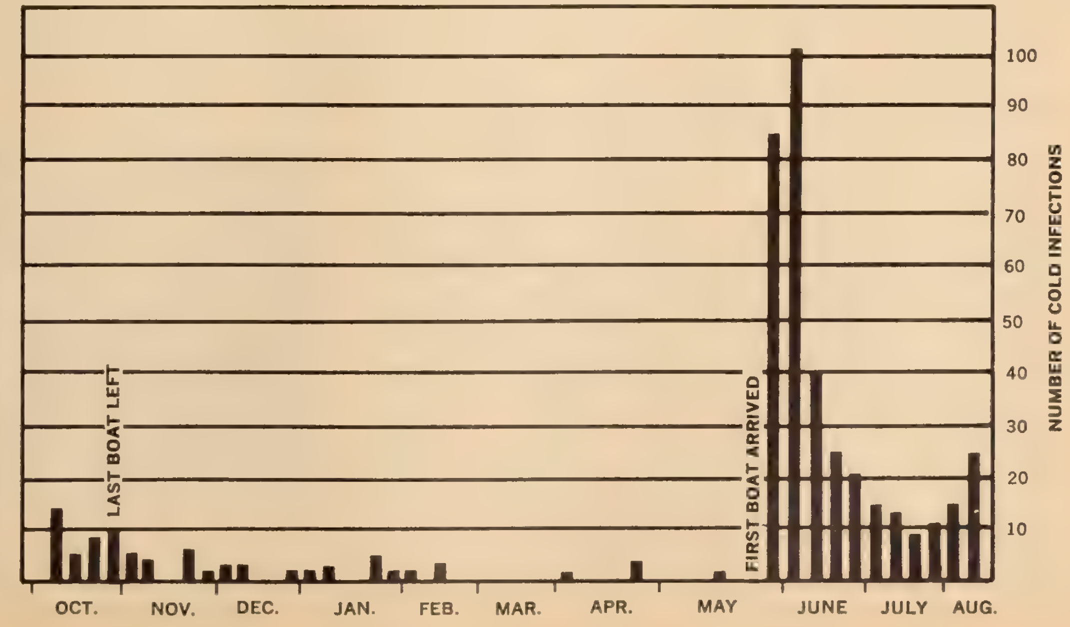
Then a fortunate "accident" happened. One incubator wasn't working right. The temperature inside dropped lower than usual. When Dr. David Tyrrell looked at the cultures the next day he saw that some of the cells had been destroyed—apparently by a virus!

By repeating the "accident"—deliberately lowering the incubator temperature—Tyrrell and his co-workers were able to get the same results. They began to find other cold viruses. Hundreds of laboratories throughout the world have since used this method.

A bewildering number of common cold viruses have been discovered and identified. One of the great mysteries

(Continued on the next page)

This graph shows how the number of cold infections changed during most of a year in a Spitsbergen city. Notice how the number of colds dropped after the last boat left in the fall. The coldest temperatures of the year came in January and March. Did the temperature have an effect on the number of colds? Why did the number of colds rise suddenly in late May?



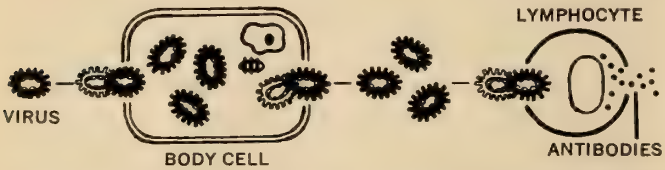
of the common cold has been explained: There is not *one* cold virus, but more than *50* different viruses that can cause the disease we call the common cold.

Why We Keep Catching Colds

This explains why we sometimes get "one cold after another." Usually when we have an infectious disease, such as measles, our bodies develop an *immunity* to it. From then on, the defense system of our bodies is able to fight off the disease *(see diagram)*. We become immune to colds too. But this resistance only works against the virus that has infected us. It doesn't protect us from the others.

Gradually, as we get older, we develop immunity to more and more cold viruses. Thus, older people are less likely to "catch" a cold.

If colds are caused by viruses, you may wonder why some people claim that they seem to catch colds after being chilled by a draft. One explanation is that just before a person "comes down with" a cold, he is more aware of temperature changes and chilly feelings. In other words, he had already been infected with a virus but had not yet developed the symptoms at the time he was chilled. Chilling probably has nothing to do with catching a cold.



Here is how you become immune to, say, cold virus number 1. The virus enters your body cells where it multiplies and attacks other cells. It also causes cells called *lymphocytes* to give off *antibodies* into your blood. The antibodies protect you against further attacks of cold virus number 1, but not against other cold viruses.

So far, there is no good treatment for any virus disease, colds included. However, a patient with a cold can be made more comfortable with aspirin and other medicines until the cold "cures itself."

The prevention of colds is another matter. Now that many of the viruses have been isolated in the laboratory, *vaccines* can be produced. Vaccines are made of killed or weakened disease germs—such as bacteria and viruses. Injected into the body, they cause changes that make a person immune to that particular disease. *(See "How Diseases Get Around.")*

Some cold vaccines have already been tried, and they seem to work. So the promise of success is at hand, but it will be a while before vaccines are made for the 50 to 100 different cold viruses. The common cold promises to be "common" for years to come ■

Having a full stomach doesn't always mean that your body is getting the food it needs for health. Food scientists are trying to help the millions of people who . . .

Eat and Go Hungr

by Steven W. Morris

■ "Put something in your stomach." Mary's m always made sure Mary ate before she went to sc Their family was poor but they always had food tc They lived on a farm in the southern United States much of their food came from the corn they grew. day Mary's mother noticed something she had al feared. Mary's skin had begun to get red blotches

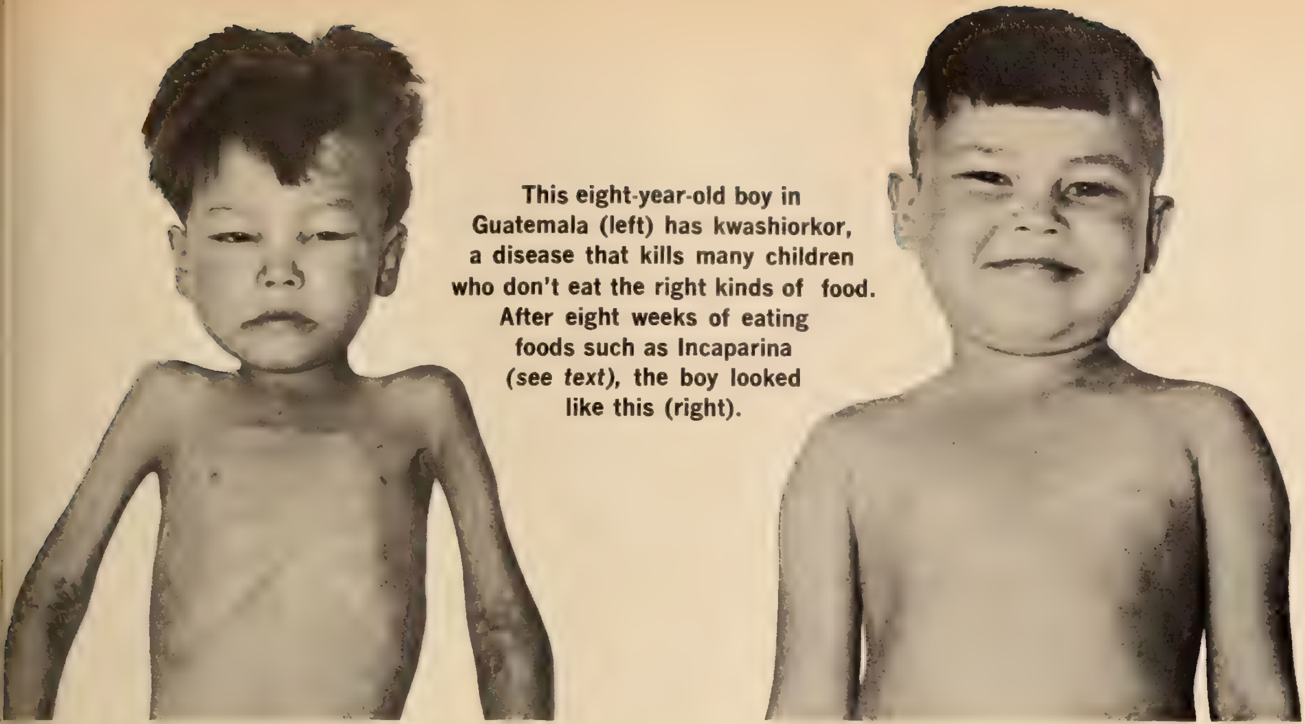
This was a familiar sign. The same thing had happ to some of their neighbors. After a while those p had become very sick. Their stomachs were always u They couldn't speak clearly. They started "seeing thi These people had the disease *pellagra,* which used t 10,000 people a year in the southern United States

More than 200 years ago an English scientist sugg that pellagra might be caused by what people ate no one tried to investigate this idea until much lat wasn't until about 30 years ago that scientists disco that a substance called *niacin*—found in such foo milk, meat, and eggs—was needed to stop the diseas

But some niacin is also found in corn. Why the pellagra strike people who ate mostly corn?

Experiments with Dogs and Rats

One of the scientists who studied pellagra is Dr. I J. Teply. More than 20 years ago Dr. Teply was a st at the University of Wisconsin, in Madison. He ar professors knew that dogs could get a disease lik pellagra of humans. Studying this disease, the sci fed some dogs a diet of mostly corn. They found th dogs often got sick and their growth slowed down scientists also tried feeding rats a diet of mostly



This eight-year-old boy in Guatemala (left) has kwashiorkor, a disease that kills many children who don't eat the right kinds of food. After eight weeks of eating foods such as Incaparina *(see text)*, the boy looked like this (right).

s don't get a disease that looks like pellagra, but the ntists found that the rats that ate mostly corn grew y slowly.

Why does eating corn seem to slow down growth and p cause disease? Why do other foods such as eggs and k speed up growth and help prevent this disease, even ugh they don't have as much niacin in them as corn ? To find out, Dr. Teply and the other scientists tested e chemicals that make up eggs and milk. They added of these chemicals at a time to the rats' food to see ny of the chemicals could speed up the growth of rats t were being fed mostly corn. One chemical—*trypto- ne*—worked.

Tryptophane helps growth. It also enables the body to ke extra niacin to fight pellagra. There is a shortage tryptophane in corn, so animals—including humans—that eat mostly corn often do not get enough tryptophane or niacin.

PHYSICAL MAP OF INDIA

Lester J. Teply points to an area in India where the ited Nations Children's Fund (UNICEF) is helping people grow foods that contain nutrients needed for good health.

The Food "Team"

In the past 20 years Dr. Teply has studied the foods of people in different parts of the world, and has investigated how foods cause or prevent disease. For the past year he has been working for the United Nations Children's Fund (UNICEF), which helps bring better health to children all over the world. When I visited him in his office at the United Nations in New York City, he explained why chemicals such as tryptophane are so important.

Tryptophane is one of many *nutrients* that our bodies need in order to grow and resist disease. There are four main kinds of nutrients, and your body has to have some of all of them. *Carbohydrates* are the sugars, starches, and fats that give you most of your energy. *Proteins* make up most of your muscle and are needed in other parts of your body. *Minerals* include calcium, needed for building bone, and iron, for making blood. The *vitamins* (including niacin) and the other nutrients help build your body and protect you from disease. If any of these groups of nutrients is missing, you will probably get sick.

"But the story isn't quite as simple as that," Dr. Teply says. "For instance, there isn't just one kind of protein, but many kinds. Protein is found in every living thing, but our bodies need certain special kinds of protein that aren't found in all foods. We get these in an interesting way.

"Every *molecule,* or smallest particle, of protein is made up of many smaller molecules of *amino acid* linked to-

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gether. There are 23 kinds of amino acids, and the kind of protein that is made depends on which kinds of amino acid molecules are linked together in the protein molecule. We think the body has to have some of all 23 amino acids to make all the kinds of protein it needs.

"After you eat," Dr. Teply explained, "your body breaks down the food proteins into smaller chunks or into separate amino acid molecules. Then it links these together into proteins that your body can use. If an amino acid such as *alanine,* for example, is missing from your food, your body can make some alanine from other amino acid molecules. But tryptophane is an amino acid that your body can't make. You must get it in your food."

In the United States, "dinner" often means meat, milk, and vegetables. Such a meal usually gives enough nutrients to keep people healthy. But two-thirds of the world's people do not eat such a dinner *(see map).* What is life like where people eat mainly bread, or corn, or rice?

Not Enough Protein

Eight years ago Dr. Teply went to parts of Africa where people often have little to eat beside the starchy roots of a plant called *cassava.* If you could have been with Dr. Teply you would have seen many unpleasant sights. He could see the outlines of the bones in the thin arms of the children. Most of the children under five years old were underweight and were not as tall as they should have been.

"In many countries all over the world conditions like this are so common that they are considered normal," Dr. Teply said. Many children he saw were suffering from sickness caused by a lack of the different amino acids their bodies need.

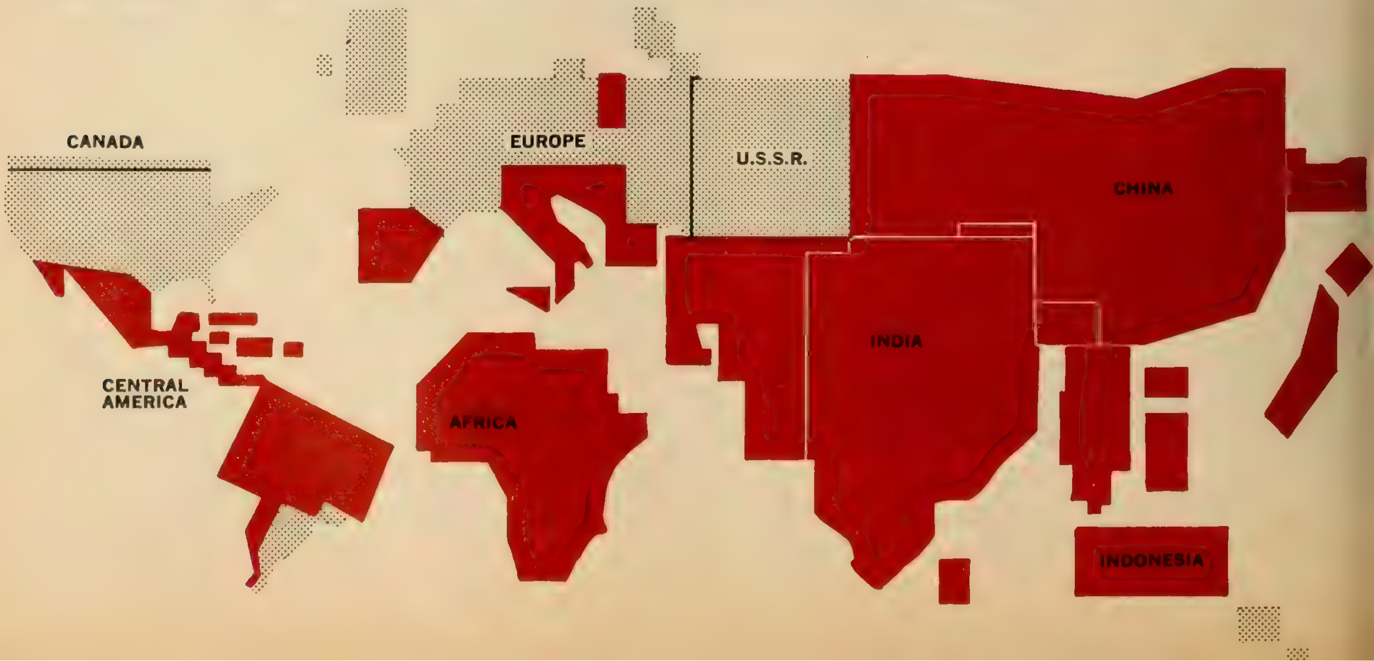
Millions of children all over the world have some form of a disease called *kwashiorkor,* an African word meaning "red baby" *(see photos).* Such diseases don't happen only in farm and jungle areas. They also affect people in cities. Many are too poor to buy milk or meat and other foods with plentiful protein, and parents often don't know how important it is for children to get enough food with all the needed nutrients.

To give everybody enough food to keep them healthy, the world would have to produce *twice* as much food as it does now, United Nations scientists think. And the problem is getting worse. Though man is producing greater amounts of food each year, the number of people who need the food is growing *faster.* Dr. Teply says that unless there is a tremendous increase in food production in the coming years, many of the world's people will starve to death. Scientists are trying to find new sources of food, especially food that is rich in protein.

Soy Beans and Sea Creatures

In South America, where people eat a lot of corn and often not enough protein-rich food, kwashiorkor has been killing thousands of children every year. Scientists tried to find a food that would supply the amino acids the people need, that would not cost too much, and that the people would not mind eating. These scientists worked at the Institute of Nutrition of Central America and Panama (INCAP). They decided to try to take a plentiful food—corn—and make it into a food that was not only

The countries shown in red on this map are those where people don't get enough of the protein foods they need for good health. The map may look odd to you; it was drawn to show a country's population, not its size. Thus Canada looks smaller than normal and India, with its high population, is shown bigger than normal.



Part of the world food problem is getting people to grow and try new kinds of food. In the state of Orissa, India, the government is encouraging people in villages to raise protein-rich fish in ponds. School children in Orissa learn to grow vegetables in basket gardens (above) that are kept off the ground to protect them from floods.

plentiful and cheap, but also nourishing. They looked for kinds of food that contained plentiful amino acids and could be added to the corn.

Two things they tried were cottonseed and soy beans. For many years people had squeezed these seeds for oil, then thrown away what was left or used it for fertilizer or food for livestock. INCAP scientists tested these seeds and found that they contain the amino acids that corn lacks, plus a lot of other protein. They found that by mixing these seeds with corn, and then adding a few vitamins, they could make a food that helped rid children of kwashiorkor. But a big problem remained: How do you get people to eat strange-tasting seeds that for years they have thought of only as animal feed and fertilizer?

The first answer was found in Guatemala. Guatemalans drink a thick liquid called *atole,* made from corn flour, which they like as much as people in the United States like malteds. The scientists ground up cottonseeds and soybeans and mixed them into atole. They called the mixture of corn and oilseed flours *Incap*arina. Hopefully, they tested the drink on some sick children. The children liked the taste. Within weeks children who were suffering from kwashiorkor gained weight, their skin became clear, and they became more alert and happy.

In the past few years Incaparina has been credited with curing many children of kwashiorkor in Central America, Panama, and Colombia. "But even more important," Dr. Teply said, "it has kept thousands of children from *getting* the disease."

In other countries where people don't drink *atole,* plant foods such as soy beans and cottonseeds are being put into cakes, soups, and many other dishes. Flour made from ground-up fish—including the scales, heads, and fins that used to be thrown away—has proved as good a protein source as meat.

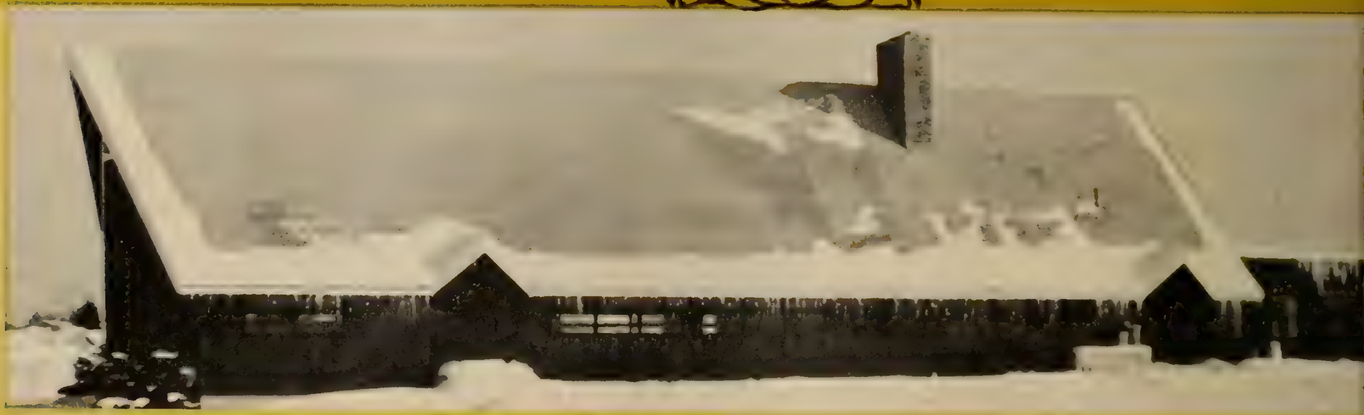
Dr. Teply and others at UNICEF are trying to get the new foods to children who need them as quickly as possible. This is easiest to do in cities where people have to buy their food. In farm and jungle areas, UNICEF is teaching people to grow crops of protein-rich plants and to raise chickens, and food fish in ponds.

Other food scientists are searching for new ways to get protein-rich food to the people who need it so desperately. Seaweed is being grown in sea "farms." New kinds of corn are being developed that give more protein and other nutrients than the old kinds. *Plankton,* the billions of tiny plants and animals that drift in the seas, are being tried as food. Some scientists think that if we can find good ways to harvest plankton or grow it ourselves, plankton may someday supply more protein than we get from all of the plants and animals on land today.

"Meanwhile we have to produce more of the kinds of food we already use," Dr. Teply said, "and find better ways to get it to people who need it." ■

prepared by **DAVID WEBSTER**

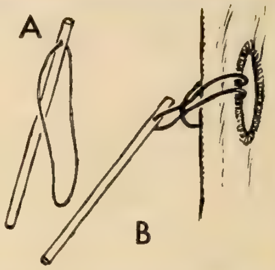
brain boosters



Mystery Photo Why has the snow not melted around the edges of the roof?

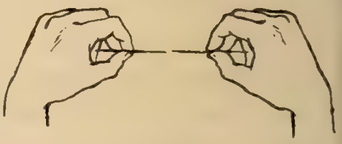
Can you do it?

Can you tie a short string to a stick as shown in Diagram A and then loop the string through a shirt buttonhole as shown in Diagram B?



Just for fun

Hold a toothpick in each hand, and try to touch them together while one eye is closed.

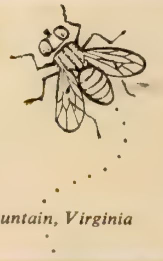


What will happen if . . . ?

What will happen if you smash up some hardened plaster of Paris into a powder and remix it with water. Will it get hard again?

For science experts only

How close does a fly get to the ceiling before he turns over and lands?



Submitted by Mary Ann Peters, Rocky Mountain, Virginia

Fun with numbers and shapes

How many surfaces has a piece of paper?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: Because there is no warm earth beneath a bridge, the surface of the bridge freezes before the road does when the air temperature goes below freezing. Why does a light snow often melt on the road before it melts on the grass?

Can you do it? To get the inside out of an egg, poke a pin hole in each end of the egg. Then blow out the inside through one of the holes.

What will happen if . . . ? The battery connected to the two bulbs in series will last the longest.

Fun with numbers and shapes: There are exactly 100 squares and other rectangles in the figure.

For science experts only: The weight of a tank will become heavier as helium is pumped into it. Even though helium is lighter than air, it still weighs something. If this is so, why does a balloon filled with helium float?

Using This Issue . . .
(continued from page 2T)

of many infectious diseases.

The WALL CHART also shows how we become immune (resistant) to a disease, either by "catching" it or by acquiring immunity through use of vaccines. (Your pupils have probably had "shots" of several vaccines, although they may not remember them; many of these vaccines are now given in a baby's first year.) The diagram "How a Vaccine Works" shows how introduction of a measles vaccine virus into the body "arms" a person against any further measles virus.

In the case of measles, the vaccine used is a "tamed," or weakened one (made less *virulent* in the laboratory). A "killed" virus may be used in vaccines of other diseases. Then the virus is unable to multiply in body cells but still stimulates lymphocytes to produce antibodies. The diagram with the article "The Most Common Disease" shows how immunity is acquired by an actual attack of a disease. For more details about virus vaccines and how they are "tamed," see "I Have a Virus . . . ," Part 1(N&S, *April 18, 1966).*

Eat and Go Hungry

The idea of having a plentiful, "balanced" diet is taken for granted in the United States. We associate the picture of underfed people with faraway places. Yet, diseases of malnutrition, including even a few cases of kwashiorkor, exist in poverty-stricken areas of the United States.

You might have your class investigate the sources and importance of different food nutrients. What are the roles of the different vitamins and minerals in the body and where do we get these substances? What are our daily sources of fats, carbohydrates, and proteins? Information on food nutrients can be found in encyclopedias, general science, biology, or health text books, as well as from teachers of high school health and home economics classes.

You may want to lead your class from this article to a discussion of the world's population *(see the special-topic issue "The Ups and Downs of Animal Numbers,"* N&S, *Feb. 21, 1966). Demographers,* who study changes in human populations, now predict that the world's population will increase by another *billion* in the next 15 years.

About half of the world's children of pre-school age are so undernourished that their physical and mental growth is retarded. In most of the "developing" countries, food production is not keeping pace with population growth. Many of these countries used to be food exporters; now most are food importers. The United States exports about 20 million tons of grain a year, but this cannot be increased and is likely to drop. The U.S. grain reserves have shrunk, despite increased acreage allotments.

Part of the answer to the world's worsening food problem may be solved by: 1) getting people to try new ways of growing nutritious food (such as fish farming); and 2) developing new sources of food (such as varieties of corn with higher quality protein). But one of the biggest problems is to close the gap in agricultural productivity on existing farm land. In the United States, farmers usually get a yield of 72 bushels of corn per acre; farmers in Morocco get 10. The Netherlands produces 65 bushels of wheat per acre; Tunisia, 7.

The difference is not due to soil quality or climate, but is due to a lack of farming technology—knowing how to develop better seed, how to use fertilizers, how to process, store, and distribute the food—*and* having the means of applying it. Most of the countries with low farm productivity still lack the "supporting cast" of fertilizers, machinery, and agricultural experts.

There must be a big increase in food production within the next 15 to 20 years to avoid widespread starvation. An even greater increase in food is needed if the present poor diets of many of the world's people are to be improved. Meanwhile, some nations are making progress in slowing their population growth by birth control programs—a logical and needed step if their peoples are ever to have enough nutritious food.

• •

Health and Disease
(continued from page 1T)

proved independently of theory. This is just another way of saying that our theories of disease are better than primitive ones. The "demon" theory led to very little improvement in treatment.

The physicians of ancient Greece and Rome developed some theories that actually led to improvements in treatment. For example, they developed the idea that the health of the body is related to the food we eat, and they investigated the effects of various diets in illness. But two hundred years ago physicians were not much further along in understanding and treating human illnesses than they had been fifteen hundred years earlier.

Microorganisms and Diseases

That many diseases are contagious, or "catching," has long been known; but it could not be guessed that the thing "caught" was a microorganism until microorganisms had been discovered. And it took a long time after that to establish the connection between the microorganism and the disease. Leeuwenhoek started writing to the Royal Society about his "little animals" in 1676. But the first clear evidence that disease might be the result of the activities of microorganisms did not come until the nineteenth century.

Oddly enough, this evidence did not involve a human disease, nor even a disease of animals. It grew out of a study of plant disease. Late in the summer of 1845, potato plants throughout northern Europe were struck by a blight that turned whole fields into black masses of rotting plants almost overnight. The consequences of this blight were disastrous —especially in Ireland, where most of the population depended on potatoes as the main source of food. During the next two years nearly half a million Irish died from the effects of famine, and two million emigrated to America.

Crop failures had occurred many times in the past, and famine, too, but this time a scientific investigation of causes could be made. Good microscopes were becoming common. It was soon found that the dying plants were full of the mycelium of a fungus. But was the fungus present because the plant had died, or was the plant dead because the fungus was present? Most people thought the former. Some disagreed.

New theories usually are not accepted quickly. Early in the nineteenth century a French scientist had shown a close connection between another

(Continued on page 4T)

Health and Disease

(continued from page 3T)

fungus and a disease of wheat. But few people knew of his work. The observations made on the potato blight, however, could not be ignored. And about 1861 another scientist, Heinrich Anton De Bary, was able to gather enough evidence to convince most biologists that the blight was a result of the fungus that had been observed in the plants.

The time was ripe for such an idea: Pasteur was disproving spontaneous generation, and Koch was soon to develop his postulates for establishing a microorganism as the causative agent of a disease [*see* N&S, *May 1, 1964, page 12*]. Before the end of the nineteenth century, the idea that "germs" (microbes, microorganisms) "cause" disease was thoroughly established—not merely among biologists but also in the mind of the public.

Kinds of Diseases

We still do not have any really satisfactory and generally accepted classification of diseases, though a few broad groups are usually distinguished. First, of course, we have the *infectious diseases,* which are associated with germs. By "germs" we mean living microorganisms. Or perhaps we should say we mean things that can reproduce—multiply. Viruses are certainly disease germs, whether we call them "living" or not [*see "I Have a Virus . . . ," and page 3T,* N&S, *May 9, 1966*].

Just as it had once been thought that all disease is caused by evil spirits, so in the late nineteenth century it appeared that all disease might be caused by germs. But disease is not so simple. We now realize that many kinds of factors are involved.

There are *deficiency diseases,* which are caused by the lack of some necessary substance in the diet. Thus, scurvy is caused by the lack of a substance called vitamin C, rickets by the lack of vitamin D, and nitrogen deficiency in plants by the lack of that major element in the soil. There are *allergies,* caused by substances in the environment that are irritating to the organism. The organism reacts in various ways, and disorders that range from skin rashes to asthma result. There are the *mental illnesses,* troubles that come from the mind but that are far from imaginary. There are *hereditary diseases,* such as hemophilia, a condition in which the blood in a wound fails to clot. And there are the *degenerative diseases,* which usually come with old age—arthritis and "hardening of the arteries."

We are only beginning to understand the complicated interactions involved in disease situations [*see note below*]. There is clearly a great deal still to be learned about even the most common diseases. In fact, the most common of all, the "cold," is among the least understood ■

Editor's note: For example, both genetics and nutrition may affect an individual's resistance to a disease. In Africa, some individuals have a substance in their red blood cells that gives them a relative resistance to malaria. This characteristic is hereditary. On the other hand, there is evidence that poor nutrition lowers resistance to disease. Measles infections are most severe among children who have inadequate nutrition.

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nature and science
TEACHER'S EDITION

VOL. 4 NO. 9 / JANUARY 30, 1967 / SECTION 1 OF TWO SECTIONS

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Each Child Has His Tempo

by Brenda Lansdown

■ When carefully selected science materials are set before a group of children, the children fall eagerly to work manipulating the materials and becoming involved with the interactions. That is, most children do. One or two may not become involved immediately. Some may even "fool around."

Does this mean that the materials are not well chosen? Not if practically every other child is productively active. Does it mean that children who are not intrigued are not mature enough for this type of freedom? Let's follow one or two and see.

Brenda Lansdown is an Associate Professor of Education at Brooklyn College of The City University of New York. The observations in this article were made from lessons taught by Darrel McOmber and Dorothy Sherman during a summer course given at Harvard University by the author.

"Fooling" or Finding?

Billy was 10 years old. He sat at a table with several other boys. On the table were flashlight batteries, small light bulbs and some wires. The boys set to work to see if they could make the lights light. Billy had such a low opinion of himself that he preferred not to try anything; and in that way he couldn't experience failure.

But Billy was active, bright, and blessed with considerable charm. While the other boys worked, rather feverishly, Billy was left out. He made funny faces, jogged his neighbor's arm, and snatched materials.

"I couldn't discover anything," he asserted loudly. The teacher said, encouragingly, "Maybe you can find out what these materials will do?"

Suddenly Billy saw that the boy op-

(Continued on page 4T)

PHOTO BY RICHARD A. BERTOCCI

When children are given carefully selected science materials, some immediately begin to manipulate the materials and see what can be done with them. A few children may not become involved right away. Some may even "fool around." Does this mean that the materials are not well chosen?

nature and science
Termites and protozoa, beans and bacteria, ants and aphids—they're all
PARTNERS
HOW OWLS HUNT

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● How It Works—Gasoline Dispenser
What happens when you say "Fill 'er up," and how the gas nozzle closes automatically when the tank is full.

● How Owls Hunt, Part 1
A biologist explains how he investigated the hunting ways of barn owls and proved they can locate tiny mice by hearing alone.

● Partners
Symbiosis means "living together," and some plants and animals live together in a way that benefits both.

● Inside a Plant Cell
By performing investigations with chunks of vegetables, your pupils can learn about the inner workings of individual plant cells.

The Secret of the Stone Spheres
How and why these round rocks were made and left in what is now Costa Rica is still a SCIENCE MYSTERY.

● The Heat To Melt Ice
This SCIENCE WORKSHOP shows your pupils how to get a rough measure of ice's latent heat of fusion.

IN THE NEXT ISSUE

A biologist describes his experiments to find out how an owl catches a mouse in the dark after locating it by hearing . . . A WALL CHART on flight . . . How moths escape from spiders' webs . . . Early attempts to find out if heat is a "fluid."

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Gasoline Dispenser

- Some of your pupils may wonder why the ventline to the storage tank is left open to admit air to the tank as gasoline is pumped out of it, since the air that gets mixed into the gasoline has to be removed in the dispenser. Ask them what would happen if the ventline were closed after the storage tank was filled? Could the gasoline be pumped out of the storage tank?

The earth's atmosphere, pushing down through the ventline, presses down on the surface of the gasoline with a pressure of 14.7 pounds per square inch. It is this pressure that pushes gasoline from the tank up to the pump as it pushes gasoline into the dispenser unit.

- You might ask your pupils if they can think of another example of a crankshaft being turned by pistons that move back and forth in cylinders, as in the dispenser meter. A gasoline or diesel engine's crankshaft is turned by pistons that are pushed back and forth by expanding gases as the gasoline or oil is burned in the cylinders.

- Ask your pupils whether they think the computer in the gasoline dispenser (described but not shown in detail) is a digital computer or an analog computer. Can they think of other devices that measure things in somewhat the same way as the gasoline computer does? *(See "Speedometer,"* N&S, *Oct. 3, 1966, page 7T.)*

How Owls Hunt

Owls have a special appeal for many people, and your pupils will probably be fascinated by Dr. Payne's description of how he studies these birds. The article also illustrates an important idea, one worth pointing out to your class: Science—the search for knowledge—is not the private domain of a few specialists.

Dr. Payne's straightforward account of his methods and reasoning leaves the impression, "Gee, that is something I could try." Sparking such thoughts ought to be one of the main goals of science education; not to increase the study of owls, but to help people to understand how science "works." Hopefully, the children who read this article will gain more than some facts about owls; they will get some insight into the *ways* of science.

Topics for Class Discussion

- *What was Dr. Payne's first step in his study of owls? How did he check his findings to be sure that they were accurate?* The author's first step was to find out what was known about owls. This meant research in libraries, searching through books and scientific journals. This should also be the first step in any science fair project or other investigation when a pupil hopes to do some original study.

As Dr. Payne writes, the owl's first catch of a mouse in the dark didn't prove anything. Was it a lucky shot? Would the owl ever succeed again? By repeating the test again and again with the owl, and then with other owls, he proved that owls could catch mice in a dark room. Then he had to be sure that the owls located their prey by hearing; the article explains how he eliminated other possibilities, one by one.

- *How can you discover what owls eat?* One way is to examine their pellets, which are wads of undigested food coughed up by the owl. You might be able to get some owl pellets from a nearby zoo, science museum, or nature center. Or, if your school is near a large park or woodland, your pupils may be able to find owl pellets under trees. The trees where owls regularly perch can be located by looking for the "whitewash" (droppings) underneath. There you will also find the less obvious pellets. A bird field guide will tell what species of owls are found in your area. (Hawks also cough up pellets, which usually contain broken mouse bones; bones found in owl pellets are usually whole.)

Some help may be needed in identifying the contents of the pellets, particularly in telling one small mammal skull from another. The book *A Field Guide to the Mammals,* by W. Burt and R. Grossenheider (Houghton Mifflin Co., Boston, 1952, $4.95) has good illustrations of mammal skulls.

Partners

All of the members of a community of plants and animals live together and are interdependent. Some of this "living together" is especially intimate, however, and is given a special name—*symbiosis.*

Some biologists apply the term "symbiosis" only to those associations that are beneficial to both parties. But to most biologists, it seems more logical and convenient to group all sorts of "living together" under the general heading of symbiosis.

The chart shows some examples of *mutual symbiosis,* or *mutualism.* Be sure to point out that the relationship between humans and their domesticated animals and plants is not truly symbiotic. Man picks his partners, and deliberately changes them (through selective breeding, for example) to benefit himself. Man was included in the chart to contrast his case with that of true mutual symbiosis.

Another kind of symbiosis is *commensalism,* where one organism i benefited and the other is unaffected. Most of the protozoa that live in ou digestive tracts are commensals, doin neither harm nor good, but living o waste material.

The chart mentions the third typ of symbiosis, *parasitism,* in which on organism benefits at the expense of th other. A parasite is an organism tha lives on or in another living organism for a considerable part of its life, derives its food from its host, and is mor or less harmful. Few living things ar free of parasites *(see page 3T).*

The chart shows only a few of man fascinating symbiotic relationships

(Continued on page 3T

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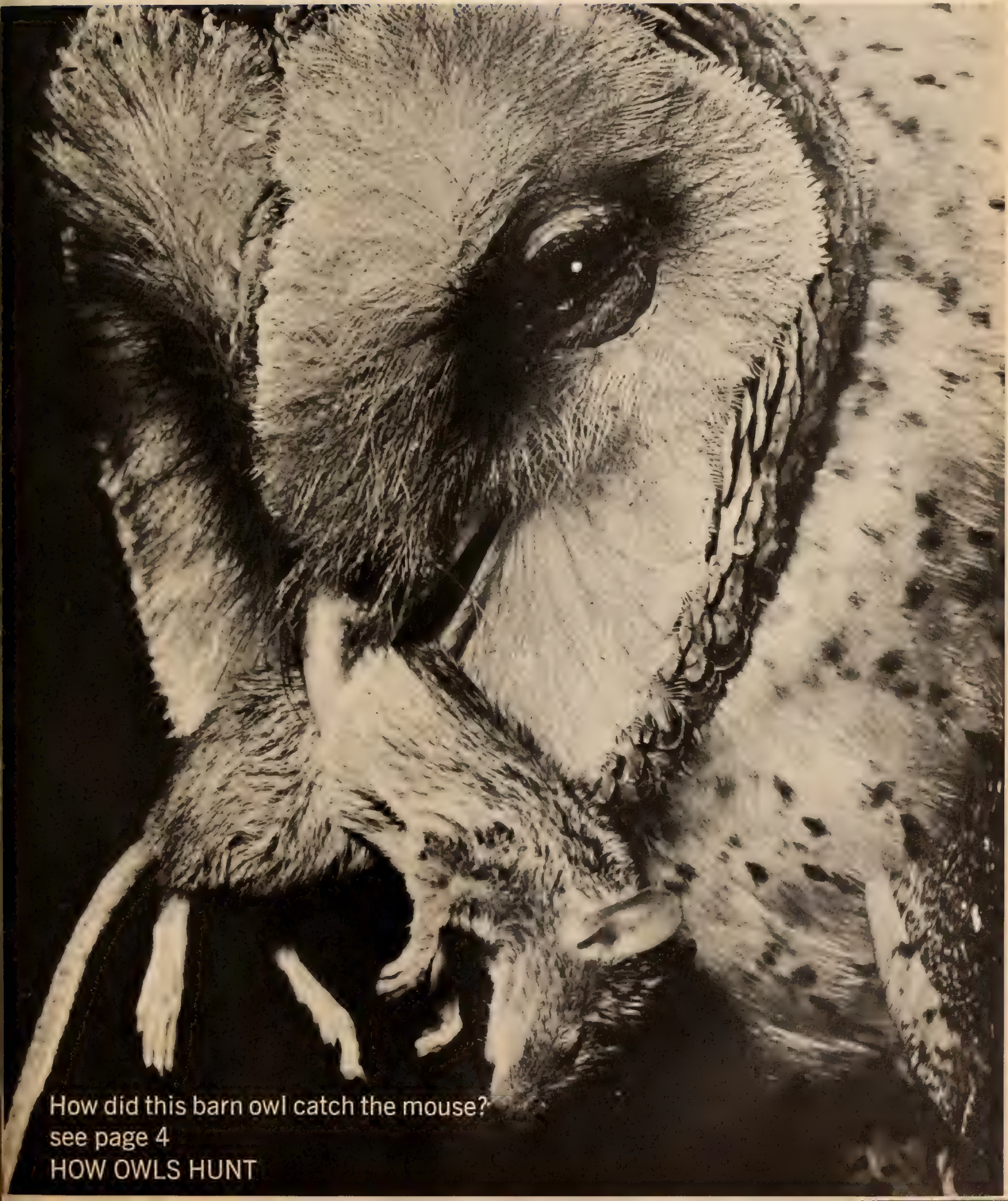
VOL. 4 NO. 9 / JANUARY 30, 1967

Termites and protozoa, beans and bacteria, ants and aphids—they're all . . .

PARTNERS

see page 8



How did this barn owl catch the mouse?
see page 4
HOW OWLS HUNT

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HOW IT WORKS

Gasoline Dispens

■ "Fill 'er up!" When the gas station attendant hear
he switches on the gasoline dispenser, sticks the
nozzle into the opening of your car's tank, and pres
trigger that lets gasoline flow from the nozzle. I
nozzle has an automatic valve, the attendant can
away to wash the windshield or check the engine oi
cause the nozzle will turn itself off when the tank is
Here is how it works.

When the attendant switches on the dispenser, an
tric motor turns the pump that brings gasoline from a
derground storage tank to the dispenser *(see Diagra*
But the dispenser is already filled with gasoline rig
to the nozzle, so the fluid from the pump flows aro
loop of pipe, back to the pump, until the nozzle is op
Then, as gasoline flows out of the nozzle, the ga
from the pump flows into the *air eliminator tank.*

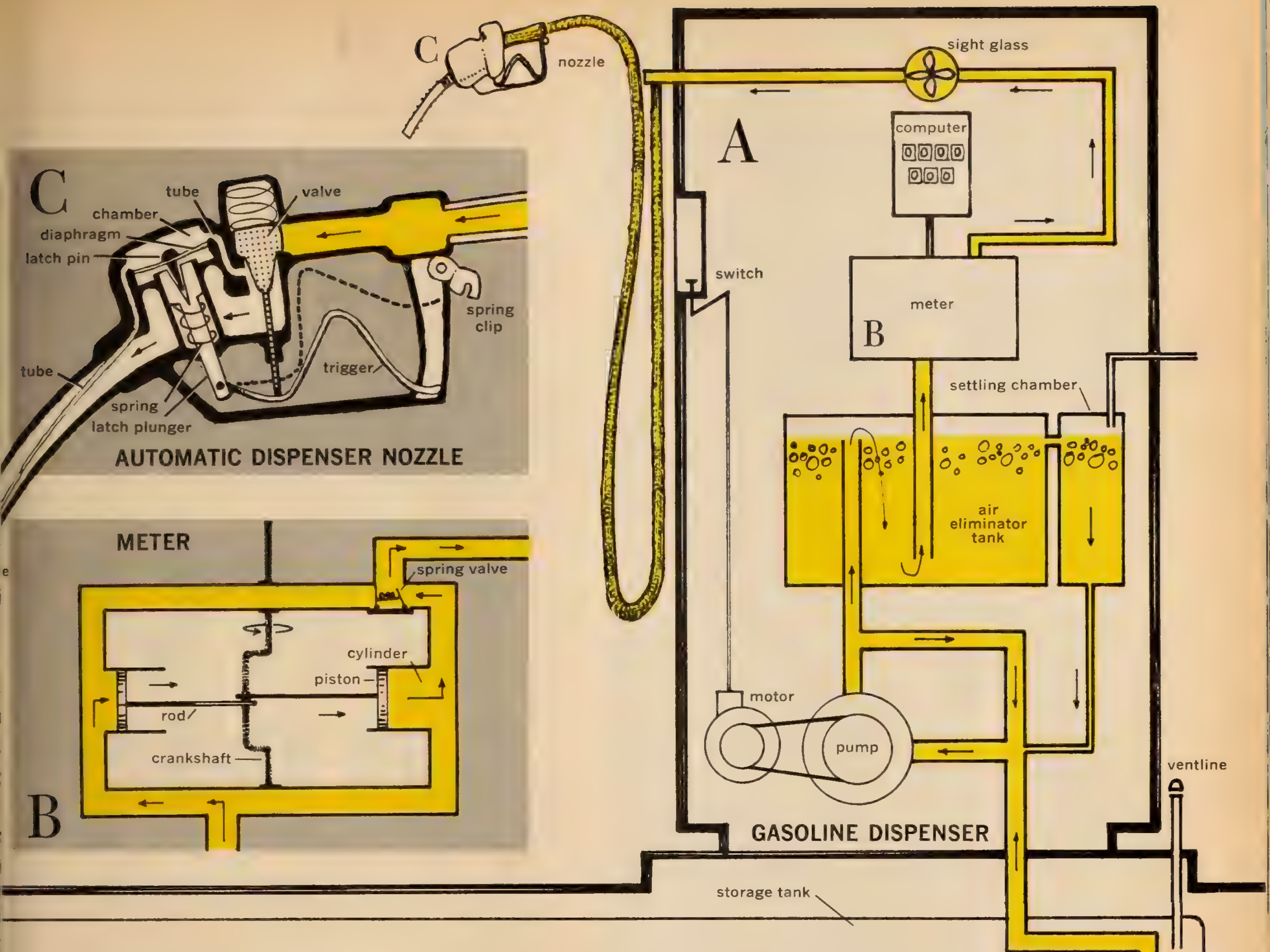
Removing the Air

The gasoline carries some air bubbles from the st
tank, which has a *ventline,* or pipe that is open at th
above the ground. The ventline lets air escape fro
tank as gasoline is pumped into it and lets air int
tank as the gasoline is pumped out of it. The air bu
have to be removed so that you pay only for gas

Since the air bubbles are lighter than the gasoline
stay at the top of the eliminator tank and run off
little gasoline into the *settling chamber (see diag*
There the air escapes into the atmosphere and the
line flows back to the pump.

From the bottom of the air eliminator tank, the
fied" gasoline flows up through a pipe to the *meter*
gasoline is measured in two *cylinders,* or chambers
pistons that move back and forth inside them to let
line in and push it out *(see Diagram B).* (Some
have only one cylinder; others have up to five cylin
A rod connects each piston to the bent section
crankshaft, which can turn inside the ring at the
each rod.

As gasoline flows into the left cylinder, it push


C
nozzle
sight glass
computer
A
switch
meter
B
settling chamber
air
eliminator
tank
motor
pump
ventline
GASOLINE DISPENSER
storage tank
C
tube
valve
chamber
diaphragm
latch pin
spring
clip
trigger
tube
spring
latch plunger
AUTOMATIC DISPENSER NOZZLE
METER
spring valve
cylinder
piston
rod
crankshaft
B

on inward, making the rod push the crankshaft around half turn. As the bend in the crankshaft moves around, ushes the other piston outward. This pushes the gaso- out of the right cylinder, through one side of a *spring e,* and out of the meter.

Vhen the piston reaches the outside end of the right nder, it no longer pushes the gasoline, so the spring e closes. Then the gasoline flows from the eliminator k into the right cylinder. The piston is pushed inward, ng the crankshaft another half turn and pushing the oline out of the left cylinder and through the left side he spring valve.

n this way, two cylindersful of gasoline give the crank- t one complete turn. By means of gears, the crank- t turns two rows of wheels in the *computer.* As the nbers around the edges of the wheels pass the windows he dispenser, you can see how much gasoline has been nped into your car and how much you have to pay for it.

Before the gasoline flows into the hose, it goes past the *ht glass.* This lets you see that the dispenser is full of oline right from the start, and a little paddle wheel turns when the gasoline is flowing into the hose.

An *automatic dispenser nozzle* stops the flow of gasoline when the car tank is full. When the trigger is pulled up and locked in place by the *spring clip,* it opens a valve and lets the gasoline flow out. It also pulls down the *latch plunger (see Diagram C).* As the gasoline flows past the open end of a tube that leads to the *diaphragm chamber,* it draws air into the chamber through a narrow tube that runs from the chamber down through the nozzle. This tube is closed at the end, but has a tiny hole near the end beside a hole in the nozzle.

When the gasoline in the tank closes off this hole, it also presses back on the gasoline flowing through the nozzle. A little of this gasoline is pushed into the tube that leads to the diaphragm chamber. It *compresses,* or squeezes, the air trapped in there. This compressed air pushes down the rubber diaphragm and the *latch pin* connected to it. When the latch pin hits the latch plunger, it pushes the end of the trigger down just enough to release the other end of the trigger from the spring clip. The trigger springs down and closes the nozzle valve ■

A barn owl must catch several hundreds of tiny field mice a year to feed itself and its young—and it catches most of them in the darkness of night. In this series of three articles, a biologist tells how he discovered...

HOW OWLS HUNT

by Roger Payne

PART 1

■ When I first began to read scientific papers about owls, I was bothered by how little was really known about how owls live and how they are able to hunt food at night. For instance, people had found that many kinds of owls have left ears that are completely different from their right ears *(see photo)*. Such owls also have special feathers on the front edges of their wings that reduce the amount of noise the wings make when the owls fly *(see diagram)*. Neither of these peculiarities is found in other birds. But no one had really tried to find out whether the strange ears and silent flight were of use to an owl.

The Barn Owl's Food Problem

One thing that was known about the lives of owls in the wild was what they eat. For instance, the barn owl is known to live mainly on field mice. People discovered this by examining the *food pellets* coughed up by owls after they have digested the meat of an animal. A food pellet is a neat, nearly dry, odorless wad of the undigested remains (mostly fur and bones) of the owl's prey *(see photos later in article)*. If you collect pellets beneath trees that owls inhabit, and tear these pellets apart, you can find out what the owl has been eating.

I had heard that barn owls eat field mice, but I thought they must catch lots of other animals because it would be hard to catch enough field mice every day. Also, barn

This article was adapted from How Owls Hunt, *by Roger Payne. Copyright © 1966 by Educational Services Incorporated, Newton, Massachusetts. This booklet was written for the Elementary Science Study project of ESI, and will be published by the Webster Division of McGraw-Hill Book Company. ESS is supported by the National Science Foundation. Dr. Payne is an Assistant Professor at the Institute for Research in Animal Behavior, run jointly by The Rockefeller University and the New York Zoological Society.*

owls have an average of nine offspring a year. So in the summer, when they are feeding their young, barn owls would have to catch nine times as many field mice. To do this at night, when it is almost impossible to see the mice, seemed extraordinary. But maybe field mice are a lot easier to see at night, when they are running all about, than in the daytime, when they are asleep in their burrows.

Again I went to the library, and again I was discouraged to find that so little was known—this time about the lives of mice. I did find, however, that it is probably very difficult for the owls to see field mice, because the mice build tunnels on top of the ground through the bottoms of grass stems. They push a path through the grass stems, chewing off any that are in the way, and stuffing the remaining bits into the side of the path or into the criss-cross stems that form the roof. Unless the mice have done a really bad job, they can move along such winding grass arbors without being seen most of the time.

Despite these tunnels, though, each barn owl probably catches up to several hundred field mice each year. I began to wonder whether the mouse tunnels work against mice as well as for them. If most of the time mice could not be seen, then most of the time they could not see danger approaching. Perhaps, too, the tunnels are not sound-proof. Besides, field mice could not spend their whole lives in the grass tunnels. The tunnels have to be lengthened and cleaned. New food has to be found, gathered, and eaten. Mates have to be met, battles fought to establish ownership over part of a field, and so on. All these activities must require leaving the tunnel. And it must be very nearly impossible for a mouse to build, gather, chew, explore, or fight without making sounds.

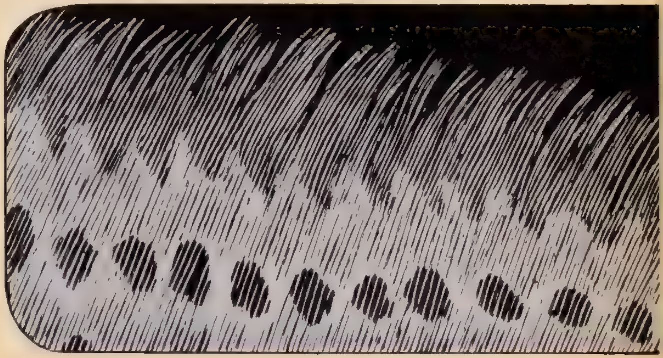
I thought about these things, and suddenly several things clicked into place—the peculiar ears of owls; their silent flight; the necessary noisiness of mice. To locate anything as small as a mouse by hearing, an owl would have to be able to follow its sounds very precisely, and, therefore, would require special ears. If the mouse heard an owl approaching, it would probably stop making sounds, and the owl would fail to find it, so the owl would need to fly quietly. Also, if the owl did not have to see a mouse at all to catch it, it would make little difference to the owl whether its waking hours were spent in light or dark. Maybe owls are active at night because mice are.

A Tame Owl Learns To Hunt

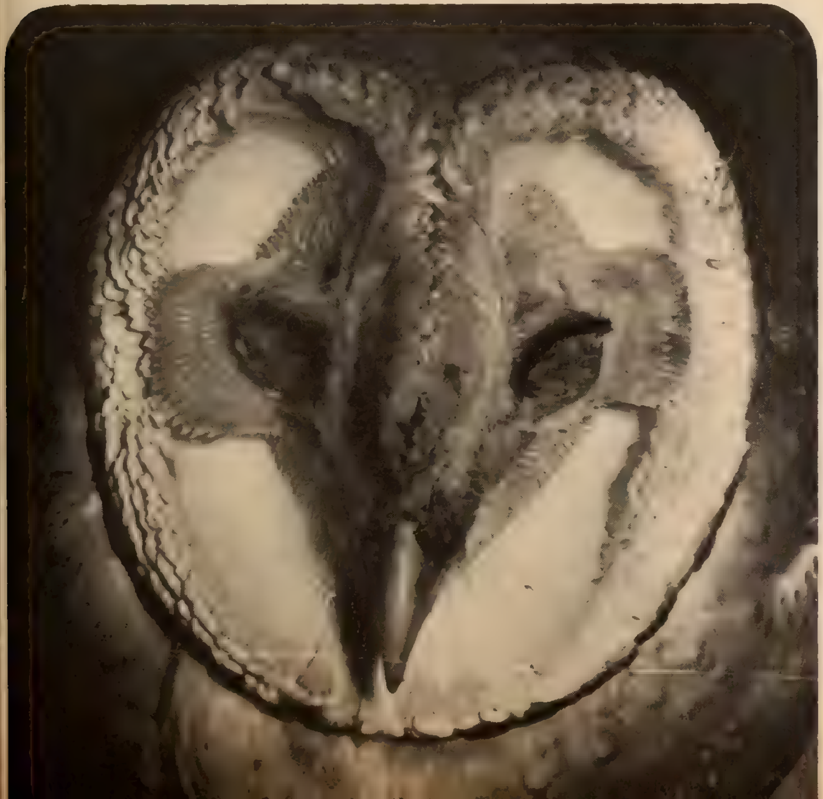
I decided to try some experiments to see whether a barn owl could catch a mouse when it could not see the mouse. I got my start working with Dr. William Drury, who ran a research station for the Massachusetts Audubon Society. We started experimenting in a deserted building near Dr. Drury's house. Having boarded up the windows in one very large room (40 feet long), I spent two weeks plugging cracks with putty and masking tape until I could see no light—even with full sunlight outside. Then, just to make doubly sure the owl could not see anything, I did my experiments only at night.

I was lucky in getting a full-grown barn owl that was quite tame. I decided that I would let the owl get used to the dark room for a few weeks, and then see if it could catch a mouse in total darkness. To be sure that the mouse

(Continued on the next page)

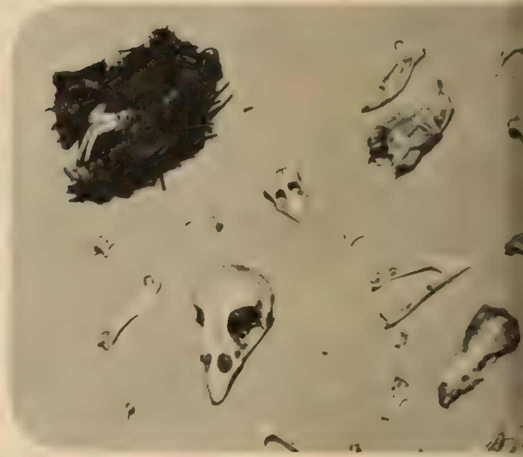


Many kinds of owls have a fringe along the front edge of their wing feathers *(see diagram)*. This fringe cuts down the noise that the wings make when the owls fly.



If you draw a line between the centers of this barn owl's eyes, you can see that its left ear flap (which covers the ear opening) is slightly higher than the right ear flap and opening. Scientists believe this helps the owl locate the direction from which a sound is coming.

This owl and its young are surrounded by food pellets—wads of bone wrapped in fur that an owl coughs up after it digests the meat of its prey. A single pellet is shown below with the skulls and some bones of a bird, a shrew, and a mouse.



would make noises when it moved about, I spread dry leaves on the floor of the room. And, to keep the owl from colliding with anything when it flew, I left the room empty except for one perch at each end.

The first time I offered the owl a chance to catch a mouse in total darkness, nothing happened. I turned on the lights, but even then the owl did not seem to know what to do. Instead of flying down to land on the mouse directly, it alighted on the floor and then caught the mouse by running it down. When an owl runs it leans far forward and takes very long strides; I felt as if I were watching a dinosaur running down its prey.

It occurred to me later that because my owl had been raised in captivity it had never seen other owls catch mice, so it might have to discover for itself how to do it. The owl kept running down the mouse, instead of flying directly to it. Then one time it launched itself into the air and came down on the mouse. Every time after that, it flew directly to the target.

A Strike in the Dark

The next time, I tried the owl with the lights off. Sitting in the still darkness, I could occasionally hear the owl shifting on the perch. I could picture it hesitating to launch itself into the pitch-black air between it and the mouse on the floor. After I gently tossed the wild mouse into the leaves, it "froze" as it landed, and waited 45 minutes before moving at all. Then it moved only a step every half-minute or so, to judge by the faint and occasional creak of a leaf. It seemed that we three—the mouse, the owl, and I—were all waiting tensely for someone else to make the first move, scarcely daring to breathe or swallow, alert to any sound.

After about 15 minutes, I heard a slight rasping sound—a sound I came later to know well—the sound of the owl's talons scraping off the perch as it started its flight. There was a moment of unbearable silence and then a crash. My hand was on the light switch; I snapped it on. To my amazement, I saw that the owl was grasping the mouse in its claws. Everything had exceeded my wildest hopes. I had witnessed, at least with my ears, an owl flying in darkness through a room longer than most houses and pinning to the floor an object the size of my thumb.

Perhaps you can understand why my immediate question was, "How on earth did the owl do it?" (It is now 10 years since that night, and still I have only some of the answers.)

I was immediately filled with doubts. Had it just been a lucky shot by the owl? Would it ever try again? Would it ever succeed again? Was it the owl's hearing, as I suspected, or some other sense that had guided it to the mouse? I hardly dared try the experiment again, but unless I did, I could say nothing with confidence.

After an hour, I released a second mouse again in the dark. This time the owl struck with even less hesitation than before. My excitement grew when I realized I had shown for the first time that an owl's ability to locate mice does not depend on training or practice. The owl I was testing had never before hunted or watched other owls hunt, yet was able to catch prey on the first try, in light or dark.

Since that first day, I have repeated the experiment hundreds of times, using four different barn owls. Again and again the same thing has happened—the barn owl catches a moving object without seeing it at all.

Was Sound the Owl's Only Clue?

I had started with the idea that an owl might be locating its prey by hearing it move, but my first experiment did not prove that. The owl might have been using one of several other clues. Mice are very smelly creatures, for instance, and perhaps owls can detect them by smell. Also mice are very warm-blooded animals, so they might be detected by the heat they give off.

To disprove these two possible explanations—heat and odor—I needed a cold-blooded mouse that did not smell. If an owl could catch such a mouse in darkness, it would have to be hearing that directed the owl's strike.

I was able to make a "mouse" to these specifications by tying a crumpled, mouse-sized wad of paper to a thread and dragging it through the leaves on the floor in total darkness. The only truly mouse-like thing about the paper wad was the noise it made as it brushed the leaves. The owl caught it repeatedly in total darkness, and thereby proved the owl could locate objects using only its ears.

There was still a problem. I could think of two ways an owl might locate its prey by hearing: It might simply follow a mouse sound to its source, that is to say, "home in" on the sounds made by a mouse. Or it might locate mice the way some bats find insects—by making loud sounds and listening for the echoes *(see "Hunting with Echoes,"* N&S, *October 17, 1966).*

To solve this problem I needed something that made mouse-like noises but was shaped utterly differently. If the owl could strike such an object in total darkness it would prove that the owl was homing in on sounds, not locating them by echoes, because any very unmouse-like object should give the owl very different echoes from those bouncing back from real mice.

My solution to this problem was to use a tiny loudspeaker. Through the speaker I broadcast a tape recording of mice running through leaves, and the owl struck the loudspeaker with ease—in total darkness.

As a final proof of my case for hearing, I plugged one ear of a barn owl with a small cotton wad and let the owl try to catch a mouse in complete darkness. It missed every time, indicating that when I interfered with its hearing it could no longer locate mice ■

How can an owl locate a mouse so accurately by hearing alone? See Part 2 of this article in the next issue.

The author, Roger Payne, was a graduate student at Dartmouth College, Hanover, New Hampshire, when he was photographed with this barred owl.

WHY I STUDY OWLS

When I was your age, I loved owls. I have always loved owls. Months could pass in which I never thought of an owl, but whenever I saw a picture of an owl, I had a special feeling. It would hit me that here was something I really cared about and that I would like to spend some time in a forest where owls lived.

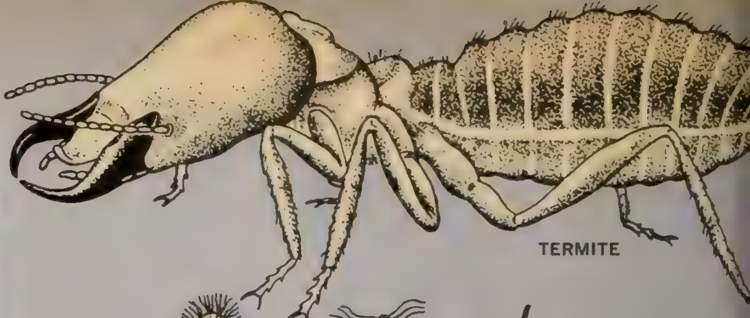
I spent summers in the country, but I was sure that owls were so special that they would never think of living in the woods near our house. So I never looked for them or bothered to ask anyone if there were any around. Long after we had moved away, I learned that we had been living right in the midst of owl country.

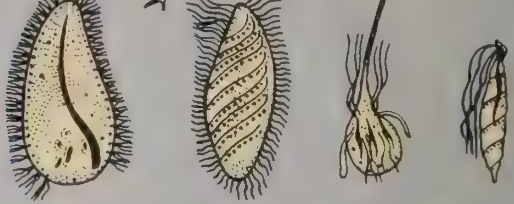
When I got to my senior year in college, I found that there was a course about birds that I could take and even get credit for. What was even better, though, was that in this course everyone was asked to spend a lot of time reading about one group of birds; to do some research if possible, and then to write about it. I chose owls before anyone else could beat me to it. (As it turned out, nobody else even cared.) It was the first time I realized that something I really wanted to do might be considered work by others—and that was perhaps the most important thing I learned in college.

Since that time I have studied owls for years at a time. I have seen them in the wild, and have kept up to 50 owls of 14 different types at one time. I have grown to like them more and more. Because I am now a biologist, I actually earn a living by studying owls. This has never ceased to amaze me, since I would gladly pay someone for the chance to study owls if only I had the money.

—Roger Payne

Partners



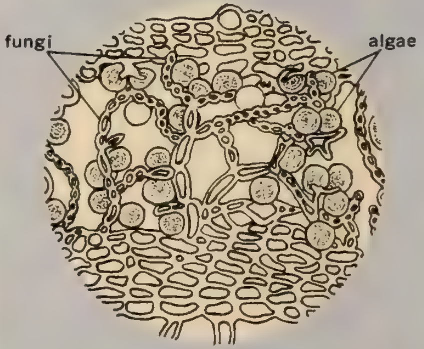

greatly enlarged view of some of the protozoa that live inside termites

■ Have you ever wondered how a termite can eat wood and digest it? Actually, a termite can't digest wood any better than you can. Living inside the termite, however, are some microscopic one-celled animals called protozoa (see diagram). These protozoa are able to break down the wood into a form that the termite can digest.

Without the protozoa the termite would starve. In turn, the termite supplies the protozoa with a steady food supply, protection from enemies, and a place to live. The termite and its protozoa are an example of what scientists call mutual symbiosis—symbiosis meaning "living together," and mutual meaning that both partners benefit.

Not all animals and plants that live together get mutual benefits. In some cases, one partner will benefit without helping or hurting the other. A parasite, on the other hand, lives on a "host" plant or animal and gets its food from the "host." The parasite does not benefit the host and usually does it harm. Fleas on a dog are good examples of parasites.

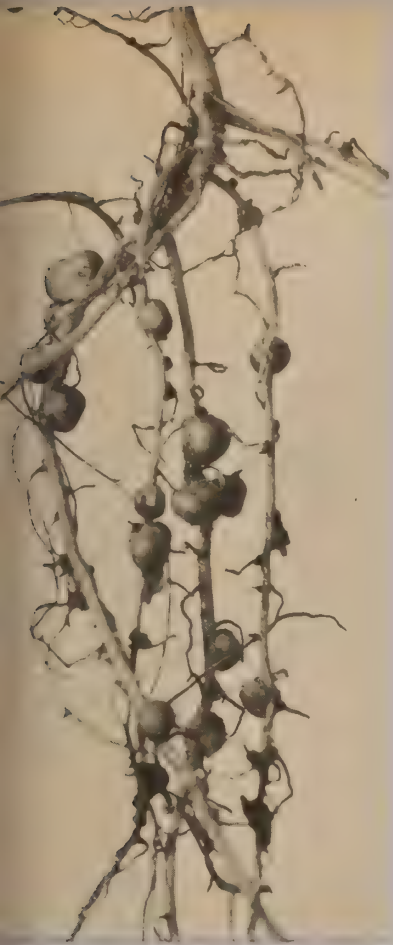
This chart shows mutual symbiosis between different kinds of plants, different kinds of animals, and between plants and animals. Next time you're outdoors, look for other "partners" in nature.—MARGARET R. BULLITT



CLOSEUP VIEW OF A LICHEN

Lichens (*ly*-kens) are combinations of two kinds of plants—algae and fungi. The structure of the fungus holds the algal cells and also traps rain water (see *diagram*). The green algae can produce food (by the process of *photosynthesis*) for themselves and for the fungi. Together, as a lichen, they can survive in barren places where neither could live alone. Lichens are common on rocks, tree bark , and in the far arctic.

Corals are animals called coelenterates (si-*len*-ter-ates). All corals give off a calcium substance that forms an outside skeleton, but not all corals build reefs. Those corals that build reefs have algae plants living in the cells that line their body cavity. The algae give off a substance that cements together the coral skeletons, thus building a reef. Coral reefs grow only in ocean water that is shallow enough for light to reach the algae, which need sunlight to make their food. Scientists believe that the coral animals get oxygen gas from the plants and the algae get carbon dioxide gas from the corals. →



All green plants need nitrogen, but they cannot use nitrogen gas from the air. Instead, they must get it from the soil, which contains nitrogen that is combined with other substances. Most green plants grow poorly in soil that is low in nitrogen compounds. However, some plants of the legume family (beans, peas, clover) can grow in such soil. These plants develop bumps, called *nodules*, on their roots (see *photo*). Inside the nodules live bacteria that are able to take nitrogen gas from the air and "fix" it into compounds which the legumes can use. These bacteria are able to "fix" nitrogen only inside legume plants, just as the legumes need the bacteria in order to grow in the nitrogen-poor soil.

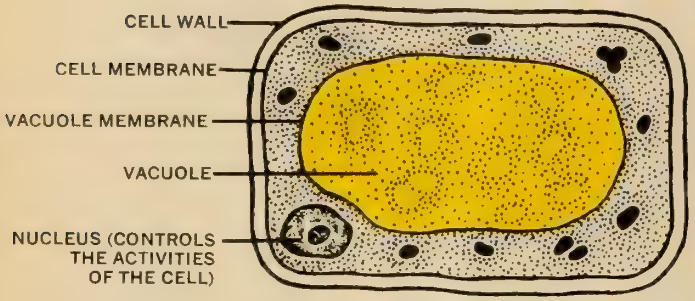
Certain ants are known as "dairy ants" because they keep tiny plant lice (aphids) as food suppliers. The aphids produce a sugar-protein mixture, called *honeydew*, on which the ants feed. The ants carry the aphids to the plants on which the aphids feed. The ants then milk the aphids by stroking them until they secrete the honeydew. The ants protect the aphids, carry them to the ant nest in wintertime, and take them out to new plants in the spring. Thus both ant and aphid benefit.

an has mutual relations with domestic plants and animals milar to the relations of ants and aphids. For example, man rds sheep and thus protects and feeds them in return for wool d meat. He also cultivates crops such as corn. Man insures e survival of his domestic plants and animals in exchange for oducts such as grain, wool, or meat. Man doesn't "live together" with sheep in the same way that the partners in a lichen do, so this can't be called a case of symbiosis. Man deliberately chooses those animals or plants that will benefit him. In true symbiosis, the partners don't "pick" each other. Their mutual relationship has evolved over many thousands of years, and sometimes the partners cannot survive alone.

With some vegetables and some simple equipment from around the house, you can investigate the workings...

INSIDE A PLANT CELL

by Deana T.



PLANT CELL

INVESTIGATION

Moving Water into Cells

Suppose you are helping your mother prepare dinner by cutting some celery or by slicing cucumbers. Then she decides to use these vegetables for a meal the following day. What is the best way to keep the sliced vegetables fresh? Here's a way to find out.

First get a rutabaga (white turnip root) from a supermarket. With a large cork borer or apple corer, remove several cylinders of tissue from the inside of the rutabaga. Lay the cylinders alongside a ruler and cut them into pieces 2.5 inches (10 millimeters) long. Then cut each piece into four cylinders of equal length. Cut cylinders of the rutabaga tissue like this until you have five groups with 10 quarter-segments in each.

Next weigh each group of 10 pieces. To do this, you can use a homemade scale like the one shown on the next page *(put your findings in Table 1)*. Then put eight ounces (one cup) of water into each of five different containers. Add different amounts of salt to each of four containers *(see Table 1 for details)*. Don't add any salt to the fifth container of water.

Put each of the five different groups of rutabaga tissue in a different container and leave them there for a half hour (at room temperature). Then take them out and gently blot each piece dry on a paper towel. Weigh each group of 10 pieces once more and write your findings in Table 1.

In which group did the cells take up the most water? the pieces and compare their hardness. If you wante keep vegetables firm and crisp for several hours, what s tion would you put them in?

TABLE 1

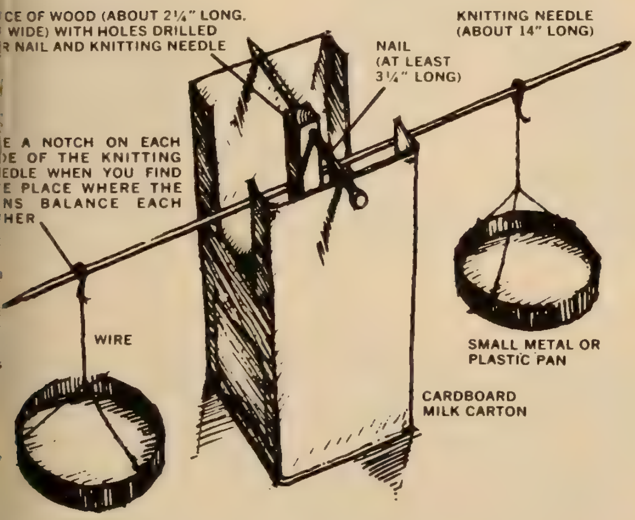
Amount of salt to mix in 8 ounces of water	Weight before put in water	Weight after put in water
none (plain water)		
½ scant teaspoon		
1 scant teaspoon		
2 level teaspoons		
4 level teaspoons		

The cells that make up plants are tiny. You need a croscope to get a good look at them. But by working h a *group* of plant cells, you can discover a lot about inside of a single plant cell without seeing it.

The diagram on the left shows what a plant cell looks e. Each one is surrounded by a cell wall, like a rigid x. Just inside the cell wall is a very thin shell or *mem-ne*. This membrane is important because it allows ter to pass freely in and out of the cell. But this same mbrane can slow down or stop the flow of other sub-nces, such as sugar. Plant scientists (botanists) call h a membrane *semi-permeable*.

In the center of every plant cell is a "tank" of water, led a *vacuole*. This vacuole is also surrounded by a ni-permeable membrane. As water enters and fills this k, the cell becomes plump. If water leaves the vacuole, cell gets limp, because the vacuole shrinks and the cell mbrane pulls away from the cell wall. If this happens a great many cells, the plant will look limp or wilted.

Using Your Homemade Balance



o weigh things on your balance, you will need to have ome things of known weight. You can make weighing nits by making wads of squares of *heavy duty* aluminum il. Here are some possible units you can use:

¼" square of heavy duty aluminum foil = .25 gram
¼" square of heavy duty aluminum foil = .5 gram
¾" square of heavy duty aluminum foil = 1.00 gram
No. 1 tinned steel paper clip = .6 gram
dime = 2.45 grams
penny = 3.12 grams
nickel = 4.8 grams

The investigations on these pages will help you discover something about the inner workings of plant cells and their unusual membranes ■

Dr. Deana T. Klein is a member of the Biology Department, Hunter College in the Bronx, New York.

INVESTIGATION

Moving Water Out of Cells

What do you suppose happens if the semi-permeable membrane of a plant cell is damaged or destroyed? You can find out by using some root tissue of a beet, which has a red coloring substance inside its cell vacuoles.

Peel a beet root and cut it into small cubes of equal size, about a half inch on a side. Make about 50 of these cubes. Set them in cold water for a few minutes, then pour the water off. Do this several times until no more red color appears in the water (this may take about an hour). Washing the cubes removes the injured cells from the outside, leaving a fresh surface.

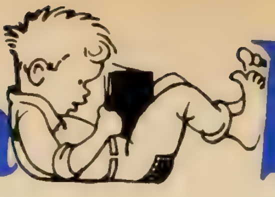
Then set up five 1-pint mason jars or mayonnaise jars and put an equal number (about 10 pieces) of the beet cubes in each jar. Finally, add a cup of a different liquid to each jar. Try the different liquids listed in Table 2.

Keep track of how rapidly the red color leaks out of the beet cubes. Which solution becomes the reddest in color? Which of the liquids added seems to have the greatest effect on the membrane around the beet cells' vacuoles?

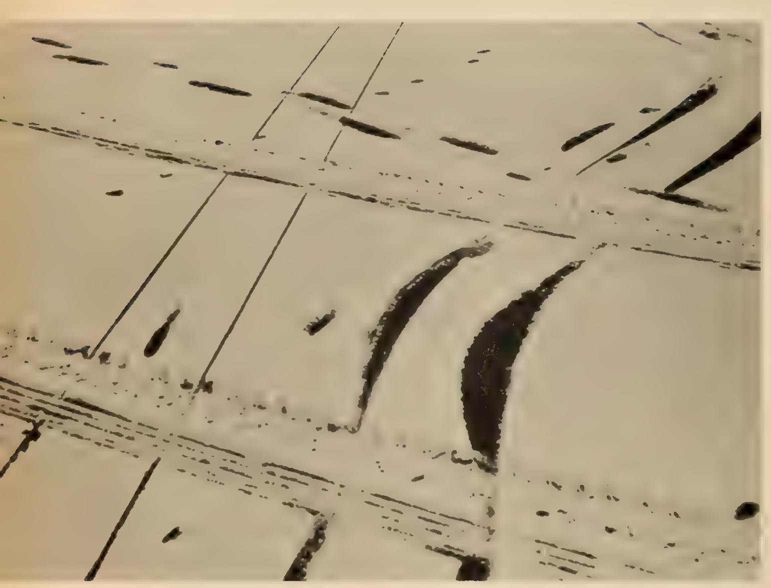
TABLE 2

Add one cup of this liquid	Color of Solution	
	after 5 minutes	after 30 minutes
cold tap water		
boiling water		
½ water, ½ rubbing alcohol		
½ water, ½ carbon tetrachloride (Carbona)		
4 level teaspoons of salt mixed in 8 ounces of water		

brain boosters



prepared by **DAVID WEBSTER**



Mystery Photo
What happened here?

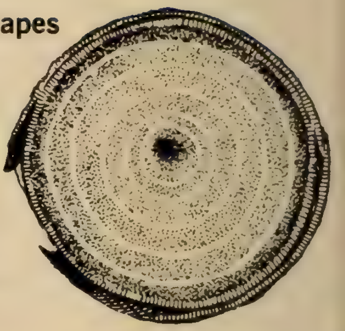
Can you do it?

Can you cut up a cube into three equal pieces without using a ruler to measure? Each piece should be the same shape and have only five faces.

What will happen if...

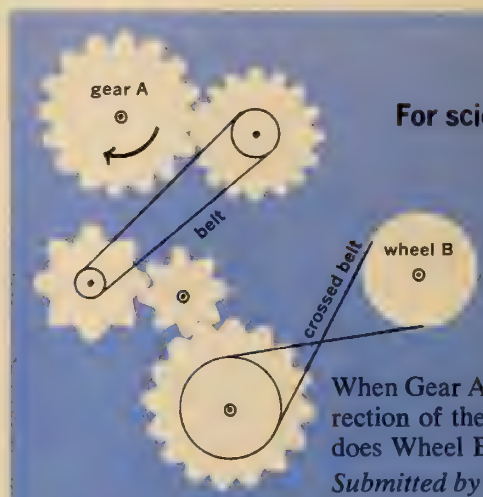
... you make soap bubbles outside when the temperature is very cold (20°F or lower)? Will the bubbles freeze?

Fun with numbers and shapes



If you cut an onion in half one way it looks like this. What will an onion look like if you cut it in half the other way?

For science experts on



When Gear A is moved in the d rection of the arrow, which wa does Wheel B move?

Submitted by Richard Berkowit
St. Louis, Missou

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

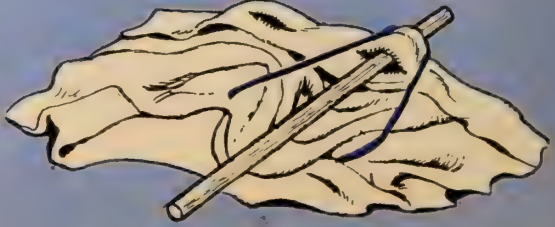
Mystery Photo: The rim of snow on the roof was left after the heat from inside the building melted the snow on the rest of the roof. Sometimes the snow on the edges of a roof melts first. What might cause this to happen?

Fun with numbers and shapes: A square piece of paper has six surfaces, the two sides that you write on, and the four edges.

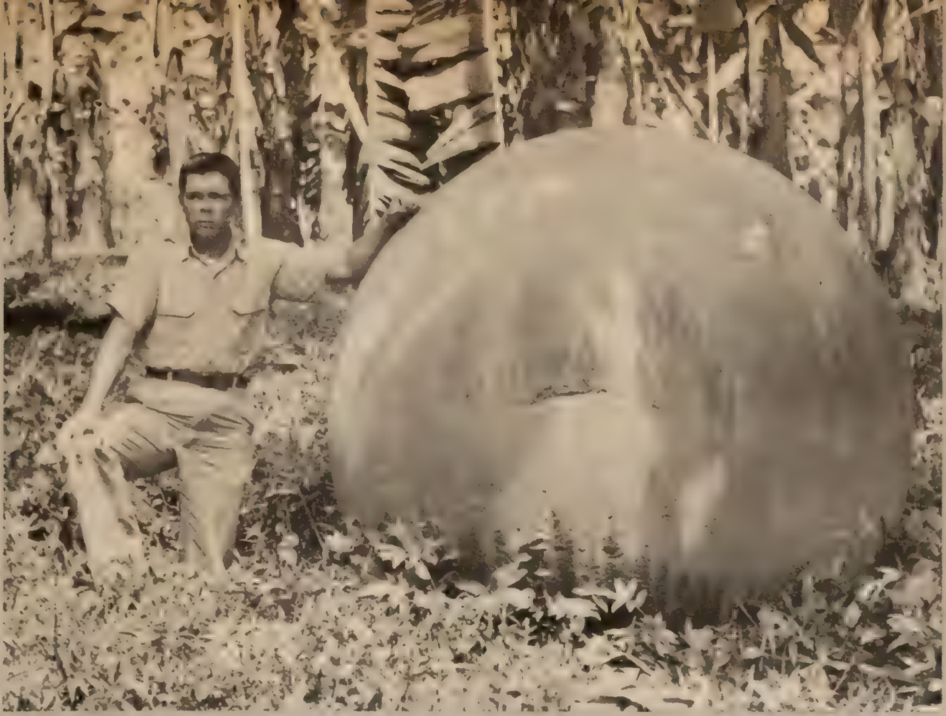
For science experts only: When a fly lands on a ceiling, he does not turn over until he touches the ceiling with his front feet (which are extended in front of his head).

What will happen if...? Plaster of Paris will not become hard if it is broken up and remixed with water. Will flour paste?

Can you do it? The problem was to push a stick, tied to a loop of string that is shorter than the stick, through a button hole so that the stick is tied to the button hole. To do this, first pull some of the hem through the loop *(see diagram)*. By using the additional length of cloth pulled through the loop, you should be able to get the stick into the hole.



Hundreds of strange, round stone balls—ome taller than a grown man—have been found in the dark forests of Costa Rica. So far, no one has been able to figure out...



This giant stone sphere on a banana plantation in Costa Rica stands taller than the author, James Harrison, who is a biologist at Mercer University in Macon, Georgia.

The Secret of the Stone Spheres

by JAMES O. HARRISON

■ In a hot, tropical forest in Central America, some workmen for a banana company were cutting their way through a thick tangle of vines about 35 years ago. They were searching in Costa Rica *(see map)* for new land where they could plant bananas. Coming to a small clearing, they found a big round stone about six feet in diameter *(see photo)*. It was almost perfectly round, and it was resting on a small platform paved with river stones.

Fascinated, the men looked around in the underbrush and found many more stones–some of them large, some small, but all of them amazingly round and smooth. The men wondered who had made these stone spheres and where they were made. The men had found no places nearby where bedrock was exposed. When they described to others what they had found, they learned that few people had ever seen these strange spheres and no one knew where they came from.

The land was found to be good for growing bananas, and the banana company soon began clearing away the forest to make way for new plantations. As trees and underbrush were cleared away, more of the stone spheres were found, as well as other small areas paved with river stones.

But the spheres have remained a mystery. Some people have thought that the largest ones might mark the graves of Indian chiefs, but digging showed there were no graves under them.

When scientists in other parts of the world learned about the stone balls, they came to see them and try to find out more about them. They found that most of the stone balls were made of granite, but a few were made of limestone. Some of the balls were only a few inches in diameter and weighed only a few pounds; others were as

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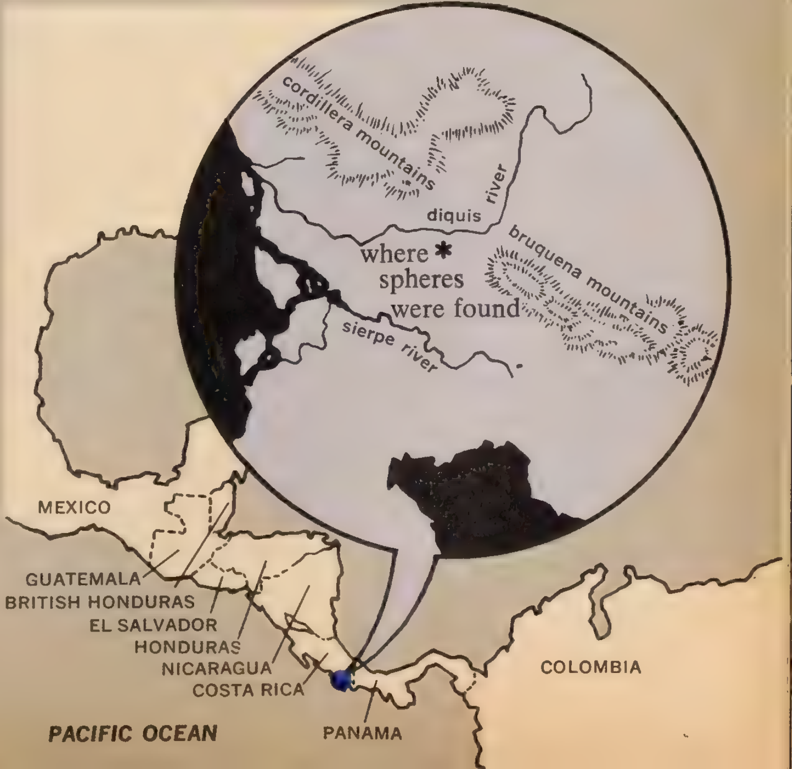

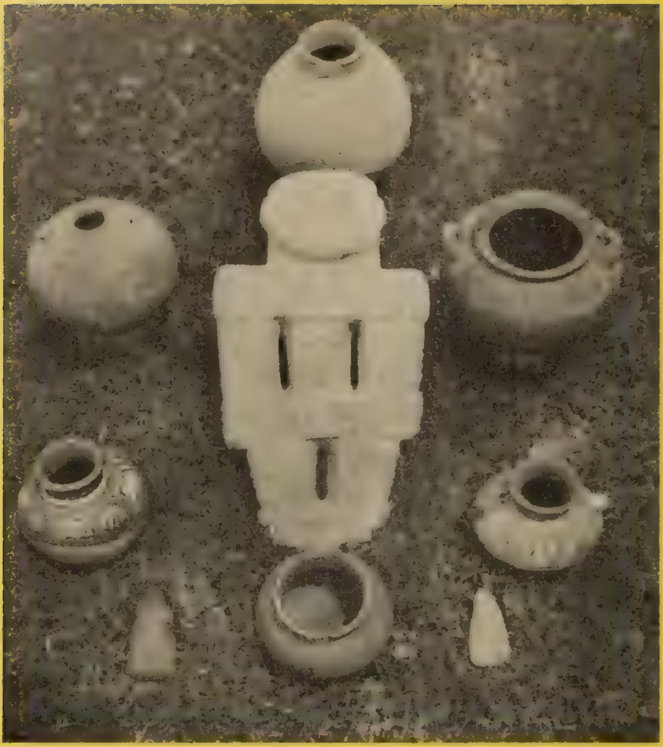

Scientists believe that these clay pots, statue, and tools may have been made about 400 years ago by the same Indians who made the stone spheres. They were found in graves near some of the round stones.

The Secret of the Stone Spheres (continued)

large as 8 feet in diameter and weighed more than 16 tons. Some of them were so remarkably round that it took very careful measurements to show that they were not quite true spheres.

In some places, clay pottery has been found with the spheres *(see photo).* Some scientists believe that the stones may have been carved at the same time the pottery was made. Studying the pottery, they found that the pieces that were made most recently were the same kind of pottery that was being made between 350 and 450 years ago. Some of the other pottery had been made centuries earlier than that. Scientists think this may mean that the round stones were also being made over a period of hundreds of years.

Spanish soldiers conquered Central and South America about 450 years ago. Scientists have searched among Spanish writings for information about the spheres, but have found no mention of them.

For Watching Stars?

The spheres were mostly found in groups of at least three and sometimes as many as 45. Some were arranged in long straight rows, others in circles, and others in triangles. Some of the straight lines point north and south. Could it be that by looking along some of the lines formed by the stones, people were able to keep track of the positions of the sun and other stars? Such information could help them predict when the seasons would change, and therefore when they should plant crops. Maybe the stones were made for religious uses. Some of the stones were found inside graves, together with pottery and gold jewelry. Scientists think this may mean that the stones belonged to persons buried in the graves.

One thing the scientists agree on is that the spheres must have been very important to the communities of people that made them. Using the tools they had, it must have taken many years to make just one ball, even with many men working on it. Scientists think that groups of workmen may have been sent away from their villages to stay for years at a time in stony areas where they could work on the spheres.

Stones on Rafts

But how did these men move the huge stones back to their villages? Even though the spheres are round, it is hard to roll the large ones because they sink deep into the soft ground. And where did they have to move them from in the first place?

Scientists can't be sure, but they have some clues. A few of the stones are carved from a kind of limestone called *coquina,* which forms when the shells of dead water animals become pressed together and form rock that is exposed when the beaches rise above water level. If the coquina balls were made on the beaches near the mouth of the Diquis River, as scientists guess, then rafts may have been used to float the balls 20 miles upstream on this main river, then at least another 10 miles on smaller streams.

The balls that were made of granite probably came from the near mountains. Except for small river boulders, there is no granite near where the spheres were found.

Today, most of the smaller stones have been taken away from where they were found. Scientists often can no longer tell what the original patterns were. People have carried many small stones away to decorate their houses and lawns. Others have been blasted to bits by people who thought they might contain gold. But some of the larger stones can still be seen on the banana plantations, and one large sphere is displayed in the courtyard of the National Museum in San Jose, the capital of Costa Rica. Some stones like these have also been found in Mexico and Guatemala.

Who made these round stones, how they were made and moved to the places where they were found, and what they meant to the ancient people who made them—the answers to these questions are yet to be found ■

THE HEAT TO MELT ICE

by Robert Gardner

Why don't ice and snow disappear from the ground as soon as the temperature of the air rises above the "freezing point"? Here are some simple investigations that will help you find out.

■ Have you ever wondered why it takes so long for ice to melt or for water to freeze? When you remove some ice cubes from the freezer, the temperature of the ice rises quite quickly to 32°F, then stays at that temperature until the ice has all melted. After the ice has melted, the water again warms up quite quickly until it reaches the temperature of the room.

When water freezes, the same thing happens in reverse. The temperature of the water drops to 32°F, stays at this temperature while the water freezes, and then falls to the temperature of the air in the freezer or the outside air (wherever the freezing takes place).

The temperature of the water from melted ice will rise until it reaches room temperature because the cold water gets heat from the warm air around it. But while ice is melting, its temperature does not change. Does this mean that no heat is needed to melt ice? This seems wrong, because ice melts faster if you hold it in your hands, and your hands feel cold because some heat from your body has gone to the ice through your hands.

How Much Heat Does It Take To Melt a Cube of Ice?

Here is a way to compare the amount of heat needed to melt a cake of ice with the heat needed to warm the same amount of ice water to 40°F. You will need a glass measuring cup or a small glass pitcher, two small drinking glasses that are the same size, a marking pen or sticky tape to mark water levels, a thermometer, some ice cubes, and a clock.

Pour water into the measuring cup or pitcher until it is about half filled, then mark the water level with the

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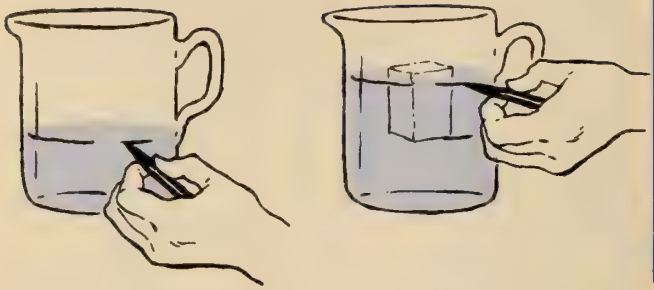
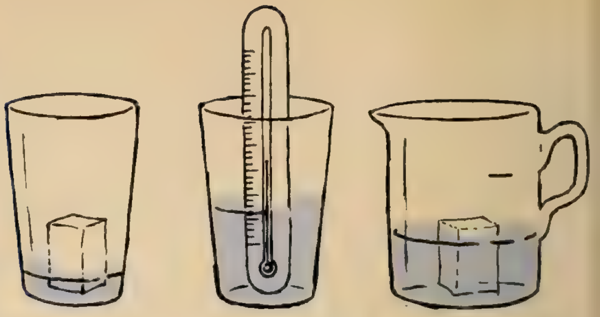




marking pen or a piece of sticky tape. Place an ice cube in the water and again mark the water level in the cup *(see diagram)*. Quickly remove the ice cube and place it in a small glass. Write down the time so that you will be able to tell how long it takes the ice to melt.

Stand the thermometer in the measuring cup, then add more ice to the water and stir until the temperature of the water becomes 32°F. (Will the temperature go below 32° if you continue to stir?) Pour water from the cup until the water level reaches the higher of the two marks you made. Now, pour the water that lies between the two marks on the cup into a second small glass. This glass will now contain an amount of water equal to the amount of water that makes up the ice in the other glass. Write down the time that you do this so that you will be able to find out how long it takes the ice water to warm up to 40°F.

Place the thermometer in the glass of cold water and wait *(see diagram)*.

How long does it take for the ice water to warm up to 40°F? How long does it take before all the ice has melted and warmed up to 40°F?

If you assume that heat goes into the ice and the cold water at the same rate—that is, that each gets an equal amount of heat from the air each minute—how does the heat needed to melt ice compare with the heat needed to warm an equal amount of water from 32° to 40°F?

If we call the amount of heat required to warm the water from 32°F to 40°F "1 unit of heat," how many units are required to melt the ice?

You might like to compare your findings with those of the Scottish chemist Joseph Black, who did an experiment like this in the 1700s. An article about his experiment will appear in the next issue ■

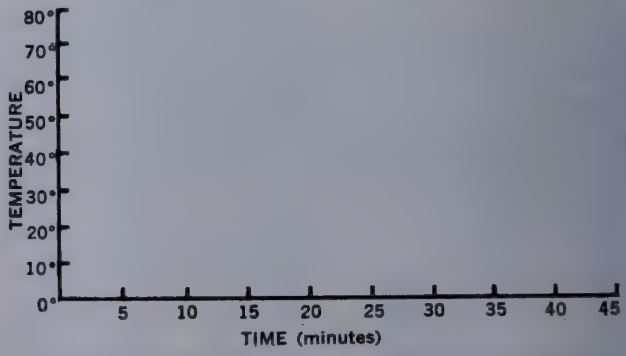
INVESTIGATIONS

- Why did you measure the time for the water temperature to rise to 40°F rather than to room temperature? To answer this question, you might compare the time it takes the temperature of water to rise from 32°F to 40°F with the time it takes to rise from 40° to 48°, or from 52°F to 60°F. Does heat seem to flow faster from warm air to cold water or from warm air to luke-warm water?

- When you placed ice in one glass and an equal amount of water in the other, did you place equal volumes or equal weights of water and ice in the two containers? How can you find out?

- Place a thermometer in a small cup of water. Be sure the bulb of the thermometer is in the water. Put the thermometer and cup of water in a freezer, or outside near a window if it is below freezing outdoors. Record the temperature of the water at 5 or 10 minute intervals until it reaches the temperature of the freezer or the outside air.

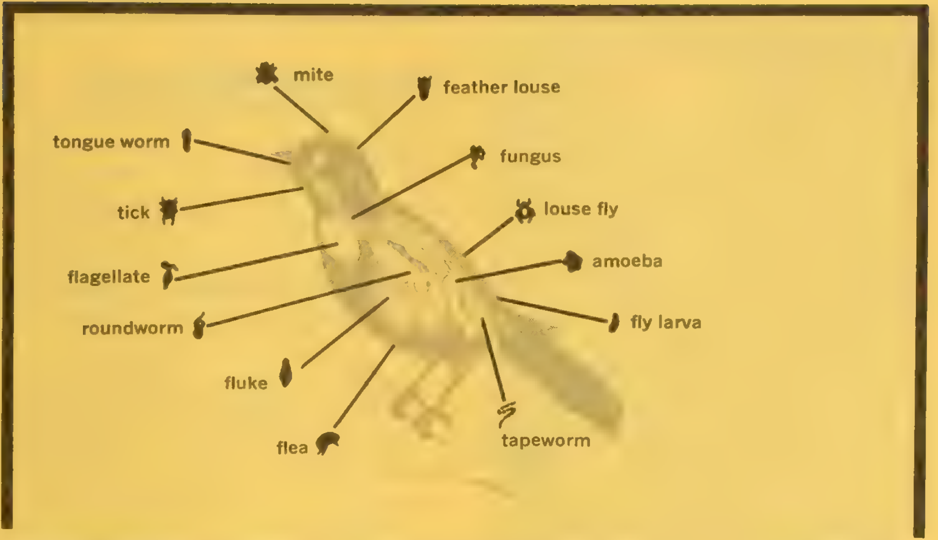
  If you mark a dot on the graph below to show the temperature at the end of each time interval, then connect the dots with a line, what will the line look like? Do you think that water loses heat to the air at the same rate (the same amount of heat per minute) when the water is at different temperatures?



Sometime after the ice has reached the temperature of the freezer, remove the cup with the ice and thermometer and make a graph of the temperature of the ice at regular intervals of time before, during, and after it melts. What does the graph look like?

Using This Issue . . .
(continued from page 2T)

You might have your class investigate others and make reports or a bulletin board display of examples of the three kinds of symbiosis.



Most living things are "home" for other organisms that live on or in them. This diagram shows some of about 20 different parasites that may live in or on a bird.

Inside a Plant Cell

By doing both or either of the investigations in this SCIENCE WORKSHOP, your pupils may get some understanding of the inner workings of a plant cell. They will see that semi-permeable membranes are important parts of these cells. The same sort of membranes enclose cells in their bodies (and the cells that make up other animals), although animal cells lack the cell walls of plant cells.

Semi-permeable membranes are made up of protein and fat. The protein part can be changed or damaged by alcohol or boiling water; the fat part by chemicals such as carbon tetrachloride.

Activities

- If your class tries the investigation "Moving Water into Cells," you might have them graph their results, with salt concentration on the horizontal axis and the weights of the tissue samples on the vertical axis. The graph will help your pupils see how the amount of salt in the water affects the amount of water that can pass through the semi-permeable membranes into the vacuole.

You might have your pupils try to guess, from looking at the graph, how much water the tissue samples would absorb in a solution of 1½ level teaspoons of salt to 8 ounces of water and 3 level teaspoons of salt to 8 ounces of water. These guesses should be recorded on the graph. Explain that trying to predict the results of an experiment from the results of previous experiments of the same kind is called *interpolation.*

Someone will probably question the accuracy of the guesses (interpolations). Ask how they might be tested. The experiment would have to be repeated, using fresh tissue samples and fresh solutions. (Two more groups of samples will be needed for the two additional solutions to be tested.)

If your pupils make this test, they may find that none of the tissue samples absorb the same amounts of water as those in similar solutions in the first experiment. Have them record their findings on the same graph as before, using a different colored pencil. From the shape and slant of the two graph lines, they can tell whether the tissues in the two experiments were affected about the same way by the different salt water solutions. And by comparing the dots on the graph for the new test solutions with the dots marking their interpolations, they can see how good their guesses were.

- The third paragraph of the article describes what happens when water leaves a plant cell vacuole. This phenomenon is called *plasmolysis,* and cells in this condition are said to be *plasmolyzed.*

If you have a microscope, or can borrow one, you can demonstrate plasmolysis in a plant cell. First get a piece of onion bulb scale—the very thin, transparent tissue found between the thick leaves of an onion bulb. Mount this tissue on a microscope slide and add a few drops of water and a cover slip. Examine the bit of tissue under a low-power microscope; you should be able to see individual cells with their walls, vacuoles, and nuclei.

Drain the water from under the cover slip by placing a small piece of paper towel at one edge of the cover slip. Then add a drop or two of a 5% salt solution (2 level teaspoons of salt mixed with 8 ounces of water) at the other edge of the cover slip. Water will leave the vacuole and it will shrink; then see if you can reverse the process by replacing the salt solution with water.

The Heat To Melt Ice

This SCIENCE WORKSHOP gives your pupils an opportunity to perform a classic experiment and compare their findings with those of the scientist who first performed it *(see next issue).*

You might point out that the "unit" of heat used in this experiment (the amount of heat required to warm water that weighs the same as an ice cube from 32°F to 40°F) is not the standard unit for measuring heat. It is used only for easy comparison with the amount of heat absorbed by an ice cube as it melts.

The amount of heat that one gram of ice absorbs in melting without any rise in temperature is called the *latent heat of fusion* of water. The same amount of heat is given off by one gram of water as it freezes.

In winter, the temperature of the air is milder near large bodies of water than it is farther inland. Can your pupils guess why? (The latent heat given off by the water as it freezes warms the air.)

Activity

Does an ice cube cool a glass of pop just because the ice is cold? Have your pupils fill two identical glasses to the same depth with warm pop from the same bottle, put a thermometer in each glass, then put an ice cube in one glass and an equal weight of ice-cold water (made and measured as directed in the article) into the second glass. By checking the thermometers, they can see that the melting ice absorbs more heat from the pop than the ice water does.

Each Child Has...
(continued from page 1T)

posite was struggling to hold several pieces of equipment in place. Billy stretched across and lent a hand. Immediately the teacher said, "That was very helpful of you, Billy."

"What did I do?" asked Billy, using the words he so often employed in self defense but now gave them the tone which bade confirmation of his hope.

"You made it possible for Pete to do his experiment," the teacher said.

Billy beamed from ear to ear. For the rest of the period, he watched the other boys work. He didn't fool around any more, nor did he try anything on his own.

Two sessions later, Billy began by putting masking tape across his mouth, and the whole group laughed, without stopping their work. They were on the road to completing various circuits. Billy then took a large dry cell and skinned an entire piece of wire. He held each end on a terminal. A look of delight crossed his face as he felt the heat in the wire.

Five minutes later he was setting up a circuit, trying to get the bulb to light. It didn't. He tried again and the light glowed. He then put a socket into his mouth and started cutting wire into tiny pieces. A minute later he was back at the short circuit activity. This time he tried to pick up a very hot wire and couldn't.

For a child who has no confidence in himself and who usually bypasses a learning experience by "fooling," has Billy made progress? Is there any evidence that he has discovered anything meaningful to himself?

A House Is a Bridge

Rick was nine and very small for his age. His teachers had always found him immature and reported that he "played house" instead of attending to studies. The second time Rick came to his science class, he rushed in ahead of everyone else and was given a xerographed copy of the statements he and his fellow pupils had dictated at the end of their first free-discovery period. This was the Scientists' Log, or record of the group's thinking *(see box)*.

Rick concentrated on reading the Log. He was not a facile reader so it took some time. When he reached the last sentence, the one he had contributed, he smiled.

The principles by which these lessons are conducted have three stages: 1) *free discovery* with structured materials; 2) a special kind of discussion called a *colloquium;* and 3) a record called the *Scientists' Log.*

By *free discovery* we mean letting people explore the materials in front of them *without any* directives from the teacher after the initial "See what you can find out." It means that the teacher reflects questions back to the experimenter with a "What do *you* think?" It means not hovering nor suggesting nor explaining; it means leaving the experimenter to develop his own unique drives along his chosen explorative trail.

The materials of course have to be carefully chosen. They are selected in such a way that manipulating them leads to a group of related concepts. In Bill's experiment the bulbs and sockets offered a stimulus to discover the effect of complete and incomplete circuits, of setting up different circuits, and finding out about the heating effects of short-circuited wires. These concrete discoveries are related to the nature of electrical energy and its conversion into heat energy. Rick's materials were related to the fact that magnets interact with nickel and iron even through layers of various materials. The idea behind this is that magnetic attraction passes through matter.

The *colloquium* is an interchange of discoveries and ideas between peers, in these cases, the children. The teacher's role is to direct the thinking without telling any facts. At the end of the colloquium the children decide what they wish to "print." The teacher acts as secretary and records those statements upon which all the children agree, both as to content and as to the manner of phrasing. Often a particular statement bears the name of the child who first made it. The *Scientists' Log* is the record of these statements. It is duplicated and given to each member of the class at the next session.—B.L.

By this time the other children had arrived and the materials were placed on the tables. There were strong alnico magnets, Canadian nickels, tin cans, glass jars, paper cups, and 6-inch squares of various materials: paper, aluminum foil, leather, cardboard, plastic.

Rick put the nickel inside a tin can and placed the magnet on the outside. He found that the nickel stuck. He then used the tin can as a telephone, carrying on an imaginary conversation with no one in particular. No one participated in this "house play" with Rick.

The other children were experimenting with the interaction of the magnet and nickel through various materials, layer on layer. Rick copied this activity, finding that the magnet and the nickel interacted through leather, paper, foil, and more leather. At this point, the array evidently looked like a sandwich to Rick. So he played at eating it!

Finally he went back to the tin can assembly. After making the nickel stick inside, he carefully removed the magnet and discovered that the nickel still stuck to the inside of the can. He and a neighbor borrowed the teacher's watch to find how long the nickel
stayed there. It was three minutes an
59 seconds.

If playing house is Rick's presen
modus vivendi to learning, wh
shouldn't he be allowed to use it as
bridge?

One of the virtues of giving childre
a chance to discover what they ca
from structured science materials i
that each child plows his own furrow
finds his own way, discovers some
thing that is important to him. Ther
seems to be no reason why discover
has to take place each minute or b
successful every time. It is the growt
of initiative and self confidence in ex
ploring the world around us that w
wish to develop in children.

By watching with great empathy th
tempo and paths to discovery that eac
child takes, we learn much about him
we learn to respect his way and the
to use this way to help him grow emo
tionally and intellectually. The feelin
of success which this method en
genders in children is enormously re
warding to child and teacher alike ■

*(Reports about new approaches to scienc
teaching are published for your informatio
and do not necessarily imply endorseme
of these approaches by N&S or The Amer
can Museum of Natural History.)*

nature and science

TEACHER'S EDITION

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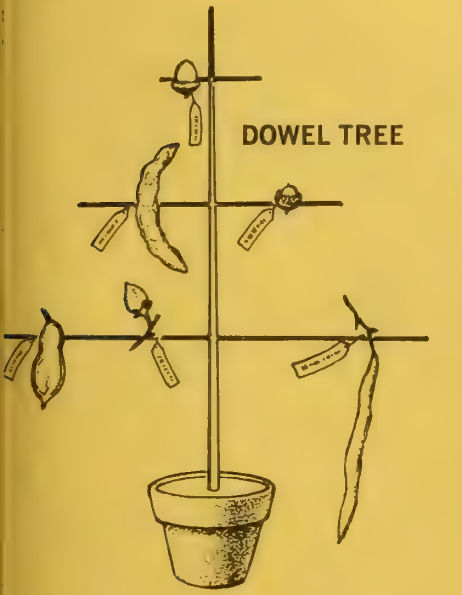
Exhibits for the Classroom

by Catherine M. Pessino

I We are often asked by teachers for xhibit ideas that can be used in the lassroom. The requisites for classoom exhibits are that they be small, nexpensive, easy to assemble, and—nost important of all—stimulating.

Here are three exhibits that have roved successful in our Natural Science Center for Young People that are uitable for the classroom or school cience room. In addition to meeting ne above requirements, they are free tanding and therefore can be moved asily from classroom to classroom. As described here, the exhibits are appropriate for the lower-to-middle elementary grades. They can be easily toughened," however, for use in junor high classes.



atherine M. Pessino is a Senior Instructor t the Department of Education of The merican Museum of Natural History, and irects the Museum's Natural Science Center for Young People.

The Dowel Tree

The "tree" is made from varying lengths of dowels *(see diagram)*. Drill holes in an upright dowel (¾-inch is a good size to use) to hold the side pieces (¼-inch). If space permits, make the tree three-dimensional by drilling the holes for the side "branches" at different angles. The tree is rooted in a flower pot with plaster of paris. Then specimens of tree seeds are tied to the branches, along with identifying labels. To stimulate children to find out for themselves more about the seeds, a label might ask: "How do these seeds 'travel'?" "When do these seeds begin to form?" "What shape leaves do these trees have?" A project can be launched with the question, "Would these seeds grow if you planted them?"

The exhibit can be varied with the seasons. In winter, evergreen cones and/or evergreen branches can be substituted.

The Test Tube Rack

Plant specimens placed in a vase or glass jar often go unnoticed. The same specimens put in a series of test tubes seem to gain in importance and are looked at and handled.

Winter tree twigs are best displayed in this way. When the twigs are placed side by side, differences in size, buds, leaf scars, and bundle scars are more evident. Your pupils can be led to make use of their other senses by feeling, smelling, and in some instances tasting. Some buds are sticky or fuzzy, some stems are bitter, some are aromatic. Use strips of tape on each test tube or on the rack for labeling. Or a general label, "How Good a Tree Detective Are You in Winter?" or "You

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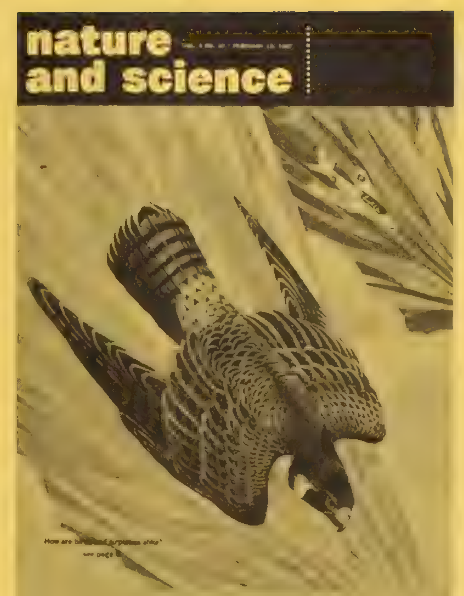


IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T-4T.)

Which Metals Hold More Heat?
Your pupils can find out, using a simple balance, thermometer, and small bits of metals.

● **An Early View of Heat**
People once thought heat was a "fluid" that flowed from hot things to cooler ones. Here's how an early scientist tested this theory.

● **How Moths Escape from Spider Webs**
Scientists discovered by accident how the scales on a moth's wings help it to survive.

● **On the Wing**
How birds' wings lift and guide them through the air.

● **When an Owl Strikes**
A biologist tells how he tested the accuracy of an owl's hearing-directed strike against its prey.

Have You Ever Been Weightless?
From their own experiences, your pupils can learn why an orbiting astronaut feels "weightless."

How It Works—Washing Machine
What the machine does, and how its actions are controlled.

IN THE NEXT ISSUE

A mammologist prepares to collect animals in New Guinea . . . WALL CHART of ocean currents . . . SCIENCE WORKSHOP: How to test the strength of paper . . . "How Owls Hunt," conclusion . . . Brain-Booster Contest winners.

Exhibits for the Classroom
(continued from page 1T)

Can Have Fun in Winter Naming Trees by Their Twigs," may be all that is needed to create interest.

In very early spring, *freshly* picked twigs placed in water can be watched as their buds open. Some buds will contain leaves, some will contain flowers, some will contain both leaves and flowers. Daily observations can be made in a notebook. Your pupils can keep a record of the gradual unfolding of the buds — by measurements and drawings.

Grasses, wildflowers, dried seed heads, plant galls, etc., can also be displayed in test tubes. If bouquets of flowers or small branches of trees are to be displayed, use 12-inch test tubes.

The Flip Board

The flip board is always a popular exhibit because the viewer *does* something. Few youngsters can resist lifting the individual panels to see if they have the correct answer.

A board 38 inches by 7½ inches with six flip panels (each measuring 5 by 8 inches) is large enough and yet easy to handle. Each individual panel is attached to the larger board by two small hinges. Corrugated cardboard can be substituted for wood. The cardboard panels can be fastened with looseleaf rings.

Here is how we have made exhibits using flip boards. In "Who Walked Here?", animal tracks were painted on the flip panels *(see diagram)*. Pictures of the animals were pasted under the flip panels. As the animals were all well known (dog, cat, squirrel, boy, deer, skunk) it was not necessary to identify the pictures in any way.

Actual specimens, such as shells, feather, fur, and minerals, were used for "What in the World?". The names were typed and pasted underneath the flip panels.

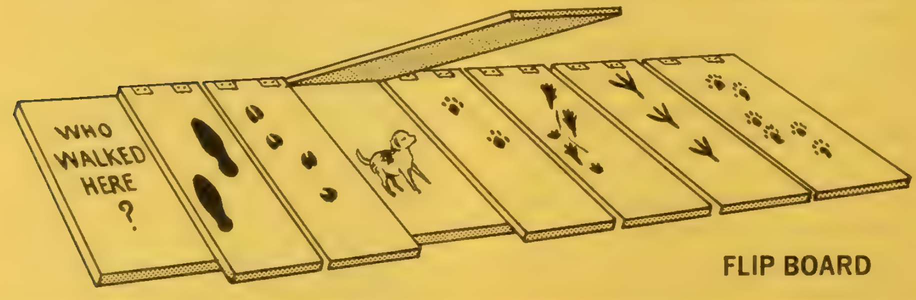
In "Who Is Looking at You?", peep holes were cut in the panels so that parts of the animal faces pasted below could be seen.

Pictures may be used on both top and bottom sections. For example, in "Animal Young," the picture of a tadpole was shown on the flip panel and the picture of a frog below.

You can make flip board exhibits like these more challenging for advanced students. One way is to ask additional questions underneath the flip panels, such as "Which way was it going?" and "How long does it take to grow up?"

References and Sources of Materials

- Pictures of animals for use in flip boards can be cut from magazines such as *Audubon, National Wildlife,* and *Nature and Science,* as well as from the inexpensive paperback Golden Nature Guides.
- *Audubon Nature Bulletins* are available on such topics as tracks, seeds, twigs, leaves, and cones. The bulletins cost 15 cents each and can be ordered from the National Audubon Society, 1130 Fifth Avenue, New York, N.Y. 10028.
- The most comprehensive book on animal tracks is *A Field Guide to Animal Tracks,* by Olaus J. Murie, Houghton Mifflin Company, Boston, 1954, $4.95. Also useful are: *Animal Tracks,* by George Mason, William Morrow and Co., New York, 1943, $2.75, and *Field Guide to Animal Tracks,* The Stackpole Co., Harrisburg, Pa., 1958, $1.50.



FLIP BOARD

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

An Early View of Heat

If your pupils have not yet investigated how much heat it takes to mel ice as suggested in a SCIENCE WORK SHOP in the last issue, you might hav them do it before reading this article which gives the findings of Josep Black, who first performed the experiment.

Today, of course, scientists kno that heat is not a fluid, but a form c energy that makes the atoms of a substance move around faster and faste as more heat energy is added to ther *(see "Exploring Heat and Cold, Par 1-3,"* N&S, *Nov. 1, 15, and Dec. 6 1965)*. The article in this issue migh be used as a springboard for introducing your pupils to the modern view c heat.

How Moths Escape

"Accidents favor the prepare mind," said Louis Pasteur. The discovery of how moths have becom adapted to escape from spider web

(Continued on page 3T

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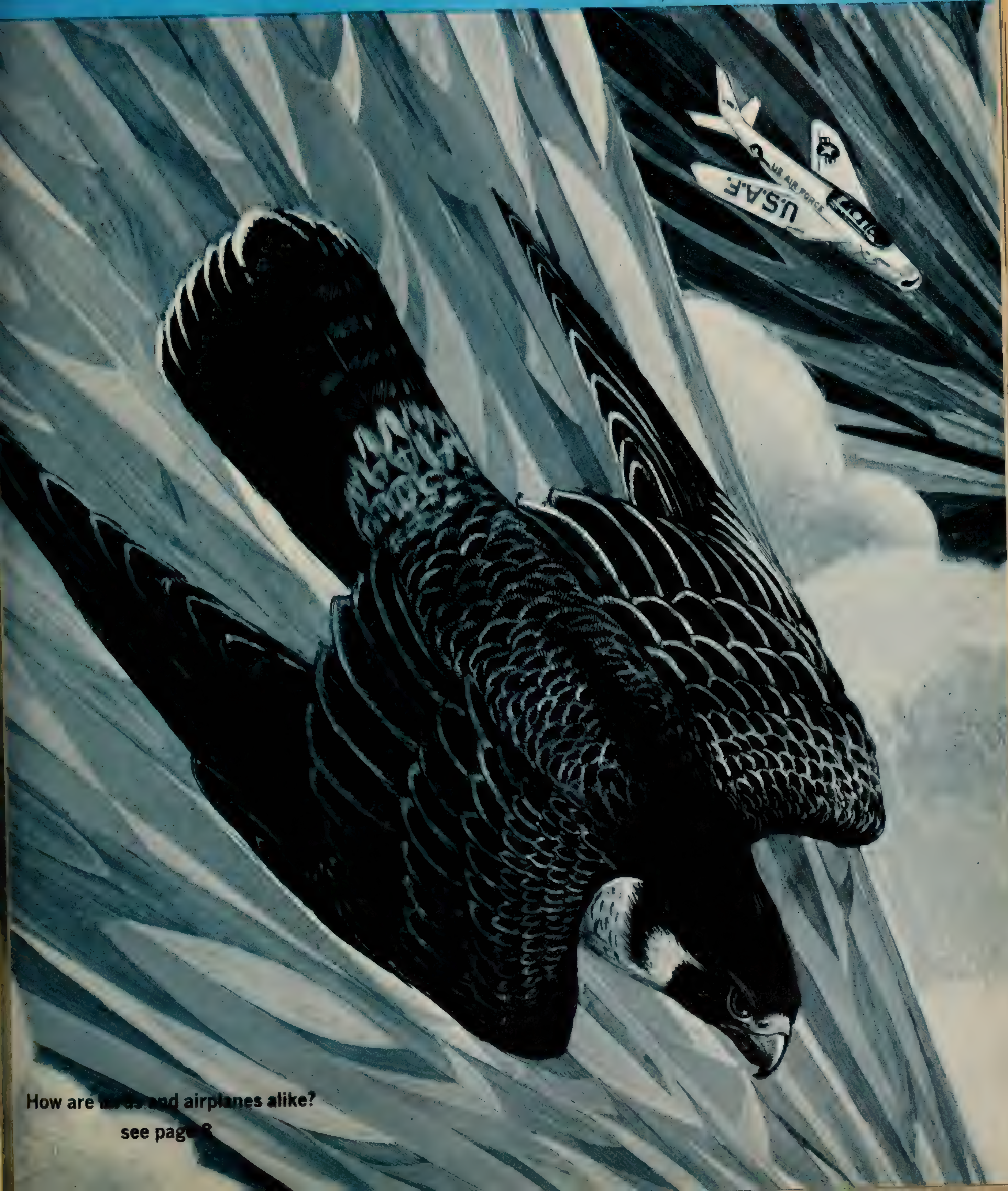
VOL. 4 NO. 10 / FEBRUARY 13, 1967

You can lose weight in a hurry on a playground swing—but not for long.
see page 15

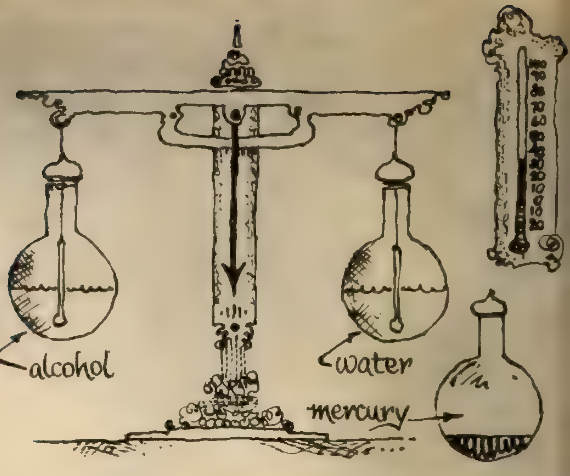
HAVE YOU EVER BEEN WEIGHTLESS?



How are birds and airplanes alike?
see page 8

An Early View of Heat

by Robert Gardner



Most scientists in the 1700's thought that heat was a "fluid" that hot things lost as they became cooler. Here is how one scientist of those times tried to prove that heat is not a fluid.

Did you try to measure how much heat it takes to melt a cube of ice, as suggested in a SCIENCE WORKSHOP in the last issue of *Nature and Science?* This article tells what Joseph Black found out when he first performed this experiment in the 1700s. How do your findings compare with his?

■ Joseph Black, a Scottish chemist, lived in the 1700s, when scientists were struggling to understand heat. As he wondered about heat and experimented with it, Black became a very good observer. He noticed that ice and snow melt very slowly without any change in temperature. Yet, when he let snow or ice melt in his hands, he could feel a large loss of heat from his hands to the ice.

Black believed that large amounts of heat were needed to melt even small amounts of snow and ice. He also realized that it was fortunate for mankind that so much heat is needed to melt ice and snow. He wrote: "Were the ice and snow to melt suddenly . . . the torrents and inundations would be incomparably more irresistible and dreadful. They would tear up and sweep away everything."

The Heat To Melt Ice

The chemist decided to compare the heat needed to melt ice with the heat required to warm up an equal weight of water 8 degrees Fahrenheit. He poured equal amounts of water into two identical glass containers. Then he placed one of the containers in a mixture of salt water and ice until the water in the container was thoroughly frozen. The second container of water was cooled until its temperature reached 32°F.

Both containers, one with ice at 32°F, the other with water at 32°F, were suspended in a large room where the temperature remained at 47°F throughout the experiment. After ½ hour the temperature of the water had risen to 40°F. The temperature in the container which held the ice did not reach 40°F until 10 more hours had passed.

Black reasoned that the same amount of heat entered the cold water and the ice in the same period of time. After all, they were in the same room and had about the same amount of surface through which heat could enter. Since it took 10½ hours to warm the ice to the temperature that the cold water had reached in ½ hour, the additional 10 hours must be due to the heat needed to melt the ice. From these results he decided that the heat needed to melt a certain amount of ice was 20 times the heat needed to warm the same weight of water from 32° to 40°F.

Joseph Black did not try to explain heat. He felt that by doing experiments he could learn more about heat and that eventually his experimental results might reveal the real nature of whatever it is that we call heat.

Other scientists who lived at the same time as Black believed that heat was an invisible fluid which they called "caloric." They thought that "caloric" flowed from warm bodies to cold ones. They thought that hot objects possessed a lot of "caloric," while cold objects had only small amounts of this fluid.

Black had shown that ice absorbs a large amount of heat as it melts. This same heat must be released when water freezes. Thinking about this, a British scientist named Benjamin Thompson suggested that if heat really is an invisible fluid, then ice should weigh less than the water from which it is formed. Many scientists agreed that weight was lost during the freezing process but said that the loss in weight was very small because "caloric" was very "light."

In an attempt to find out whether water did lose weight when it froze, Thompson got a very good balance that could weigh things that were very light. The results of his first experiment indicated that water *gained* weight when it froze, but he was not satisfied with his experimental methods. He thought that moisture could have collected on the surface of the container or that air currents might have moved the balance arm slightly. "So," in his own words, "I determined now to repeat the experiments with such variations as should put the matter in question out of all doubt."

Thompson knew that it takes more heat to raise the temperature of a pound of water one degree than it takes to raise the temperature of a pound of alcohol one degree. And the alcohol needs more heat than a pound of mercury to raise its temperature one degree. This means that if the same weights of water, alcohol, and mercury are cooled the same number of degrees, the water gives off more heat than the alcohol, and much more heat than the mercury.

With this in mind, Thompson poured equal weights of these three fluids into three bottles of the same size and shape. He hung thermometers in the bottles containing the water and the alcohol, but none in the bottle containing the mercury. (Since mercury gains and loses heat faster than water or alcohol, he knew that when the temperatures of the water and alcohol were equal, the mercury would already be at that same temperature.)

The three bottles were carefully sealed and left in a warm room until their temperatures were all the same.

PROJECT

Can you think of a way to find out whether the weight of ice changes when it melts?

After carefully wiping the bottles to remove any dust or moisture, Thompson weighed them on a balance and attached small pieces of wire to the necks of the bottles until they all had the same weight.

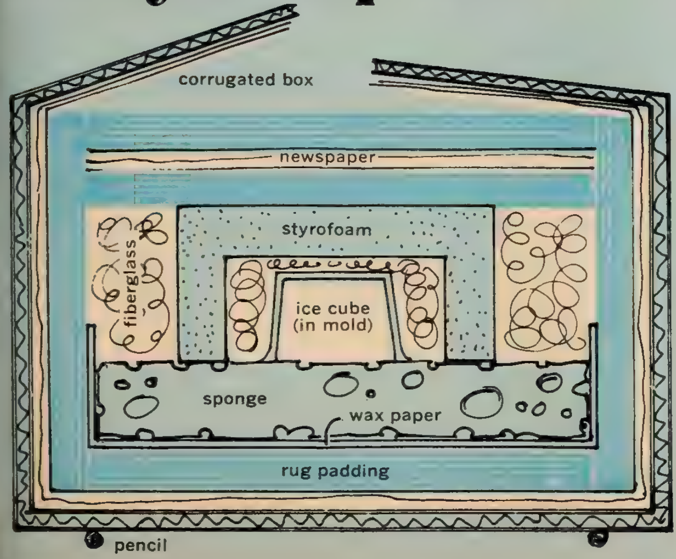
The bottles containing the alcohol and the water were hung from opposite ends of the balance and placed in a cold room where the water would freeze. The bottle of mercury was placed near, but not on the balance. Thompson returned two days later to find that the water had frozen, but–as he had hoped–the balance was still level. The temperature of all three containers was 30°F.

The water had lost a great deal of heat when it changed to ice. The alcohol had not frozen and had not lost as much heat as the water; yet, it was still the same weight as the water. The mercury, which Thompson knew had lost very little heat, was then suspended from the balance in place of the alcohol. It too weighed exactly the same as the ice.

Thompson repeated the experiment a number of times. The results were the same each time. Despite the large heat losses when the water froze, it did not appear to lose any weight. Thompson believed this showed that heat did not have weight and could not be an invisible fluid.

Do you think the scientists who thought of heat as "caloric" accepted Thompson's conclusion? If not, how do you think they explained his results? ■

Can you top this?



Ethan Merritt, 14, of Cleveland Heights, Ohio, is the new World's Champion Ice Cube Keeper *(see "Can You Make a Better Ice Cube Keeper?",* N&S, *December 5, 1966).* The diagram shows how he did it.

To keep warm air from reaching the ice cube, he first lined a corrugated cardboard box 6½ by 8½ by 7 inches with a ¼-inch thick layer of newspapers. Then he lined the box again with rug padding ¾ of an inch thick. He cut and glued pieces of styrofoam plastic to make a box that would hold the ice cube in its mold with fiberglass window insulation wrapped around the mold.

Then Ethan figured that water from the melting cube might fill some of the air spaces in the rug padding and the water would not block heat as well as the air would. So he lined the bottom with wax paper and placed a sponge under the ice to soak up the melt water.

He packed fiberglass around the cube container and placed layers of rug padding and newspapers over it before closing the top and putting two rubber bands around it to keep it closed. Finally, he placed the box on top of two pencils to get an insulating air space all around the box.

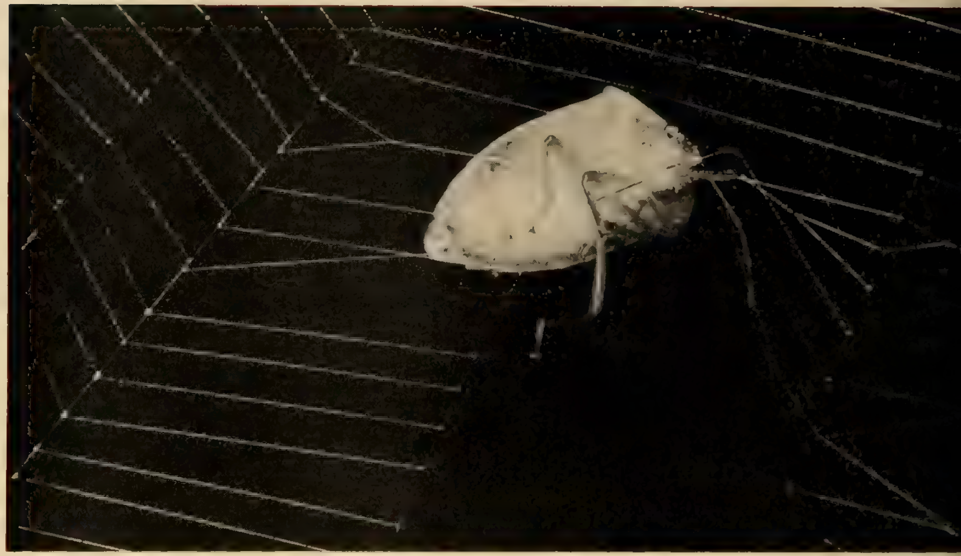
In this ice cube keeper, Ethan found he could keep an ice cube about 20 hours. And by putting his keeper inside a portable ice chest, he could keep a cube even longer.

Mosquitoes and other flying insects swarmed around three biologists one night. In ridding themselves of the insects, the biologists discovered . . .

How Moths Escape from Spider Webs

Scientists have accidents . . . their plans go awry . . . they "goof"—just like everyone else. From time to time, events like this have led to important discoveries. But in order to discover something "by accident," a person must keep his mind open. He must be willing to change his plans, to try new ideas.

The following story tells how, one night, the plans of some biologists were changed by a swarm of annoying insects. Because of this "accident," they discovered . . . well, we'll let one of the biologists, Dr. Thomas Eisner (a professor at Cornell University in Ithaca, New York) tell you himself.



This stink bug is gripped by the sticky threads of an orb-weaving spider's web. As the bug tries to get free, its struggles alert the spider, which pounces on it, wraps it in silken thread, and feeds on it.

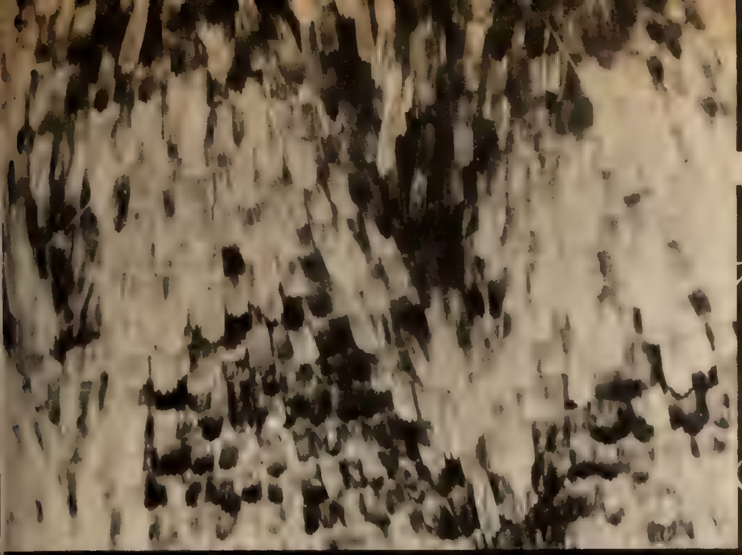
■ In the summer of 1963, three biologists from Cornell—Rosalind Alsop, George Ettershank, and I—were staying at The American Museum's Archbold Biological Station near Lake Placid, Florida. We went out one night, prowling among the shrubs and palmettos, collecting millipedes. Each of us wore a spot lamp strapped to his head, so both hands were free. Soon we were surrounded by dense swarms of mosquitoes and other flying insects that were attracted to us and to our lights.

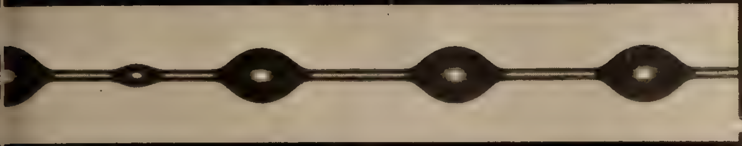
Just then, we happened to wander into an area where the webs of orb-weaving spiders were very abundant. The webs, ranging in diameter from a few inches to several feet, seemed to stretch everywhere around us. Someone suggested: Why not get rid of the insects by luring them into the spider webs? We tried it and it worked.

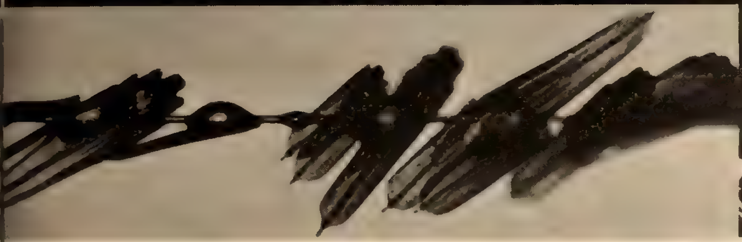
We would stand for a moment among a group of webs. Many of the insects flew into the webs, were caught, and stopped bothering us. We were so fascinated by the spiders themselves that we spent the rest of the night there, watching them feed on their big catch.

The orb webs had a framework of non-sticky supporting threads and a spiral of sticky ones *(see photo)*. When an insect hit the web, it was caught in the sticky threads and its struggles alerted the spider. *(For information on other kinds of spiders and their webs, see "Eight Ways*

Adapted from an article in the June-July, 1965, issue of Natural History *magazine.*







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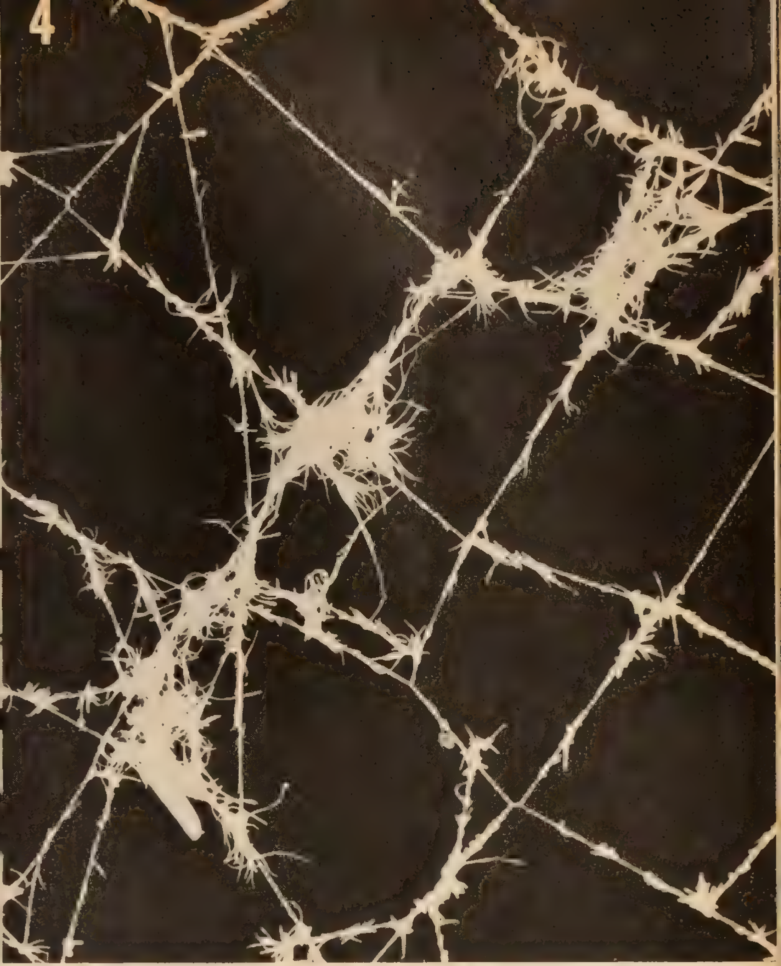


The wings of moths are covered with tiny scales, like the shingles on a roof (Photo 1). When a moth flies into a spider web, it strikes against threads that are made sticky by evenly-spaced drops of a glue-like fluid (Photo 2). Some of the moth's scales stick to the drops (Photo 3), allowing the moth to get free. When a moth escapes from a web it usually leaves a "moth scar" of damaged threads and patches of scales (Photo 4).

To Catch an Insect," N&S, *Oct. 3, 1966.)*

In order to discover more about the fate of different kinds of insects, we set up what we jokingly called the "web test." Two of us would get on opposite sides of a web. Then one person would shine his light about, trying to lure a particular kind of insect close to the light. If he succeeded, he would suddenly switch off his light. The insect would then be attracted to the light of the person on the opposite side of the web. The insects that hit the web and stuck there "failed" the test. Those that managed to escape "passed."

Beetles, lacewings, hemipterans, and moths all flew into the webs. Time and time again, only the moths "passed" the test. The moths, especially smaller ones, would strike the sticky threads, then break away and escape. We wondered why.

One clue was "moth scars," patches of tiny scales from the bodies and wings of the moths that stuck to the web *(see Photo 4).* Could it be that a moth's outer coat of scales enables it to escape from spider webs?

Long after that summer night in Florida, we investigated this idea by seeing how well spider thread stuck to the wings of different kinds of insects. We tested pieces of "naked" wings from insects such as flies and grasshoppers. Then we tested "coated" wings, from moths and caddisflies. Comparing the results, we found that the naked wings stuck to webs about three times tighter than coated ones.

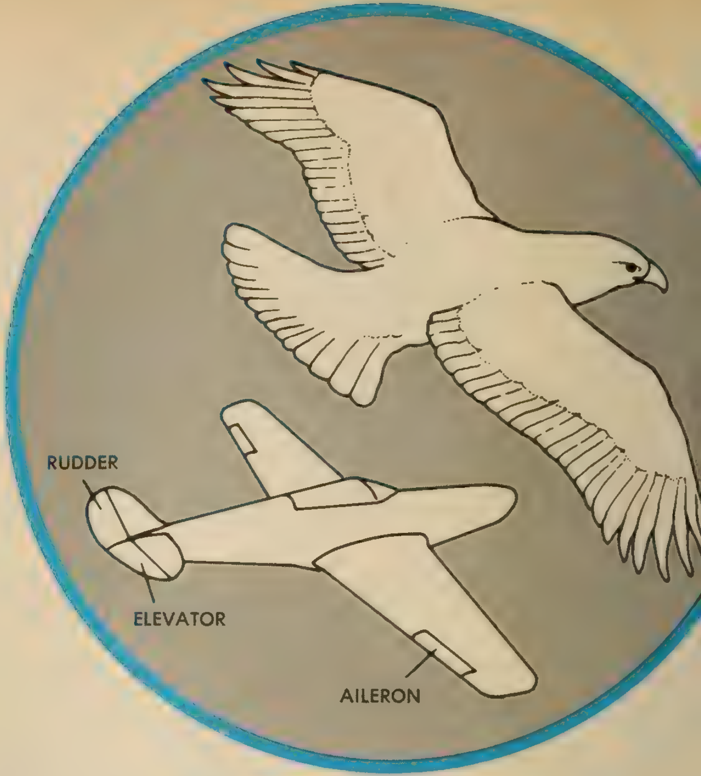
Until recently, biologists had always thought that the scaly coats of moths helped their flight in some way. Now a new possibility has arisen. Although scales do not regrow on moths, there are enough on a moth's body and wings to allow it to escape from several spider webs. Also, if you have ever tried to hold a moth by its wings, you know how slippery they are. Perhaps their scales help them slip away from some of the animals that try to catch and eat them.

The scales on moths apparently help them survive, and this is probably one reason that their scaly bodies and wings have evolved over many thousands of years. This discovery gives us a better understanding of why moths—and other kinds of animals—are formed the way they are. And it all began with a swarm of annoying insects on a summer night.—THOMAS EISNER

on the wing

■ What is it like to speed through the air under your own power? Despite his flying machines, man will probably never know what the free flight of birds is really like.

Having wings is only a part of what one needs to fly. A bird's feathers, light-weight bones, lungs and air sacs, and fast-beating heart all help make it a living airplane. The bodies of birds have become adapted for flight during millions of years of evolution. The drawings on these pages show some of the ways in which birds are adapted for flight, and how birds and airplanes are alike ■


RUDDER
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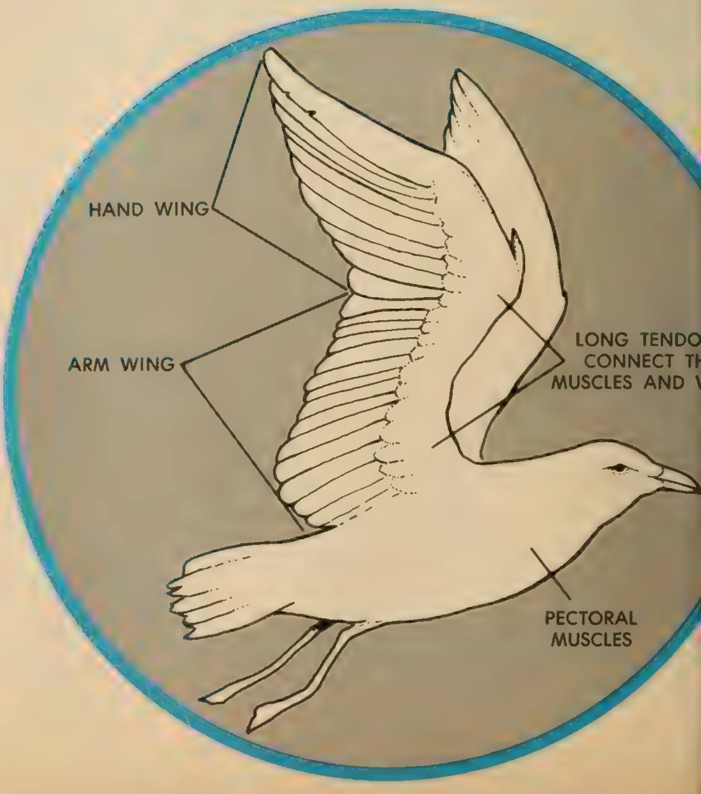
HAND WING
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r by tilting their wings
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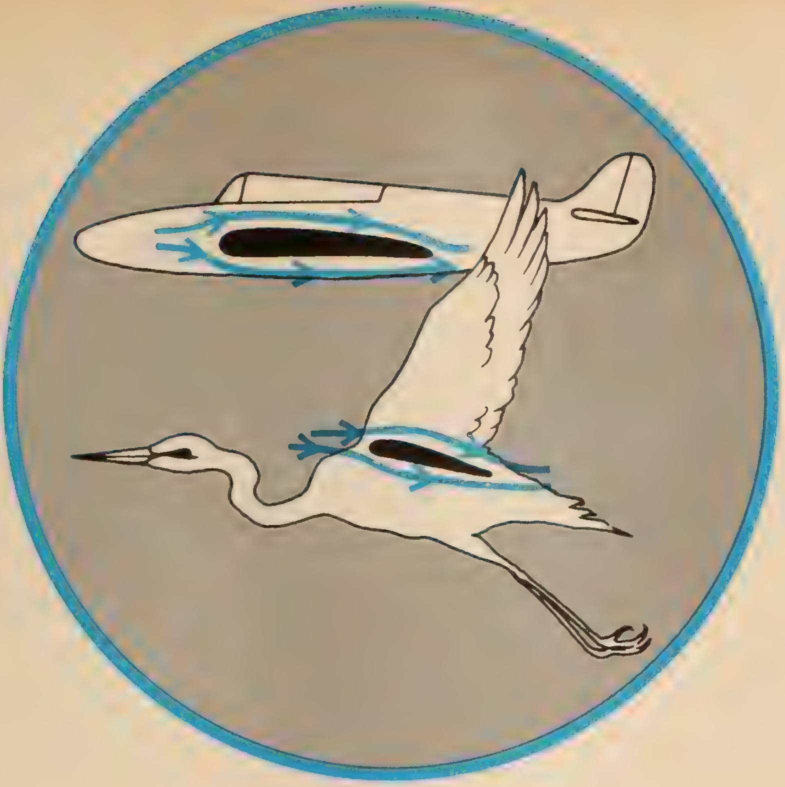
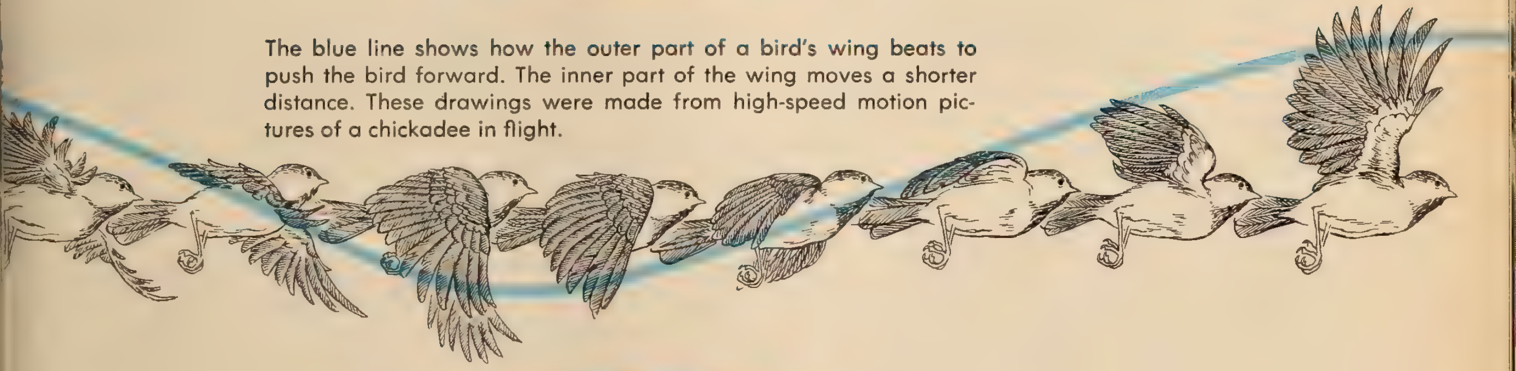


As a bird or airplane wing cuts through the air, some of the air flows over the top and some underneath. The air moving over the bulge on top has to travel farther, and therefore faster, than the air moving under the wing. Because of its faster speed, the air on top does not push downward as much as the air underneath pushes upward, so the wing rises. This force is called *lift*.

The blue line shows how the outer part of a bird's wing beats to push the bird forward. The inner part of the wing moves a shorter distance. These drawings were made from high-speed motion pictures of a chickadee in flight.



ring has a double job,
wing and propeller.
the body, the "arm"
es only a short dis-
nd down. Its job is to
bird's body lift, like
of an airplane. The
outer part of a bird's
ves as a propeller,
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ng is powered by
ast *(pectoral)* mus-
eat such muscles
have "white meat"
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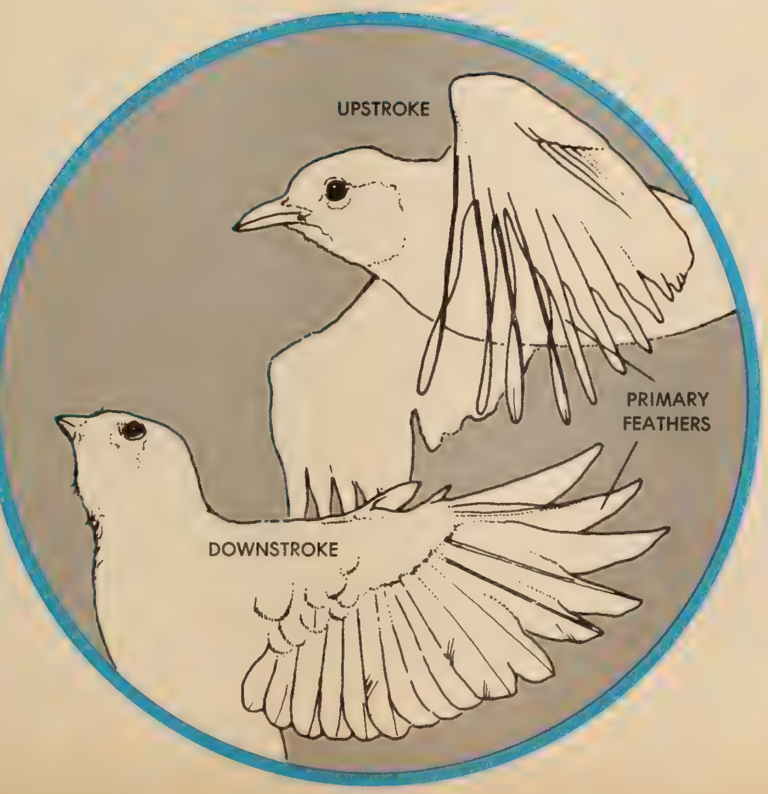
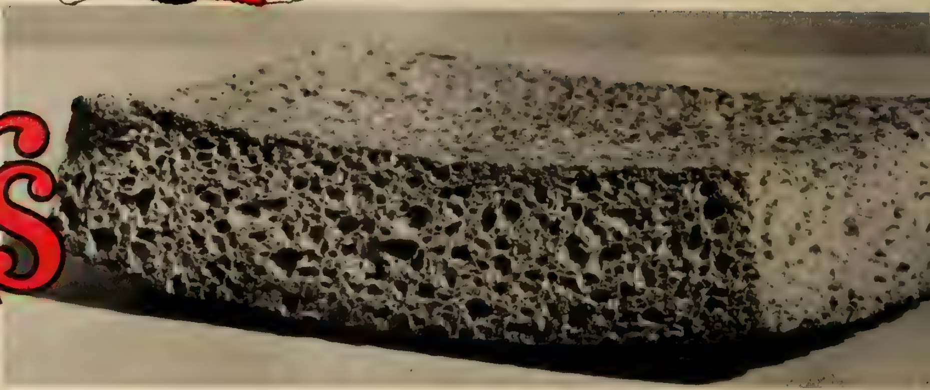


On the downstroke, a bird's "hand" wing moves down and forward. The big *(primary)* feathers overlap each other, making a strong, broad surface. On the upstroke, the primary feathers open to let the air slip through, making it easier to raise the wing for the next downstroke. In going through upstroke and downstroke, a bird's wing tip makes a figure-eight pattern.

Brain Boosters

prepared by **DAVID WEBSTER**



MYSTERY PHOTO Why has the sponge curled up as it dried?

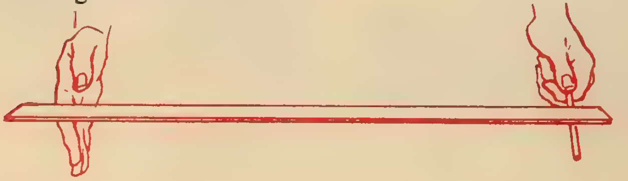
CAN YOU DO IT?

Can you use two mirrors to make 10 reflections of your eye? Try it with a hand mirror and the bathroom mirror.

Submitted by Darcy Spencer, Santa Rosa, California

WHAT WILL HAPPEN IF?

What will happen to the yardstick as you slowly move your hands together?

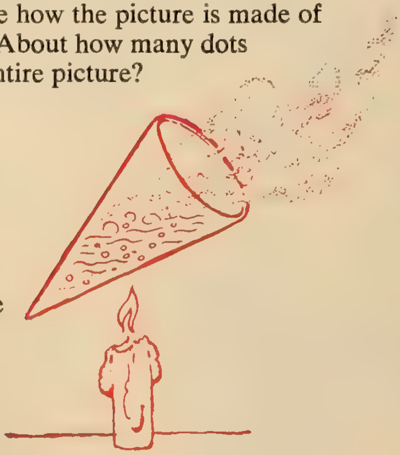


FUN WITH NUMBERS AND SHAPES

Look at the Mystery Photo with a magnifying glass. Can you see how the picture is made of many little dots? About how many dots are there in the entire picture?

FOR SCIENCE EXPERTS ONLY

Why is it possible to boil water in a paper cup?



JUST FOR FUN

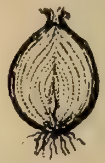
You can feel water pressure by covering your hand with a plastic bag and then putting it under water. (Don't let the water get into the bag.)

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The wide tracks in the snow were made by two automobiles. The two pairs of narrow lines are sled tracks. One sled traveled straight, while the other sled made several small turns.

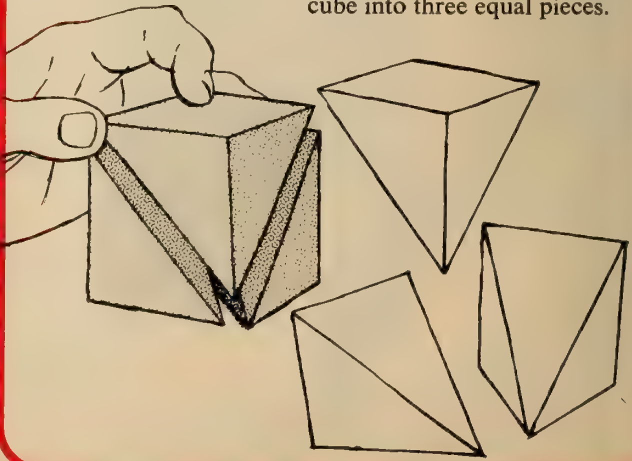
What will happen if? If the weather is cold enough, a soap bubble made outside will freeze before hitting the ground. When this happens, the floating bubble shatters into many frozen pieces.

Fun with numbers and shapes: Here is how an onion looks when cut in half through its top and bottom. What vegetables or fruits would look the same no matter which way they were cut in half?



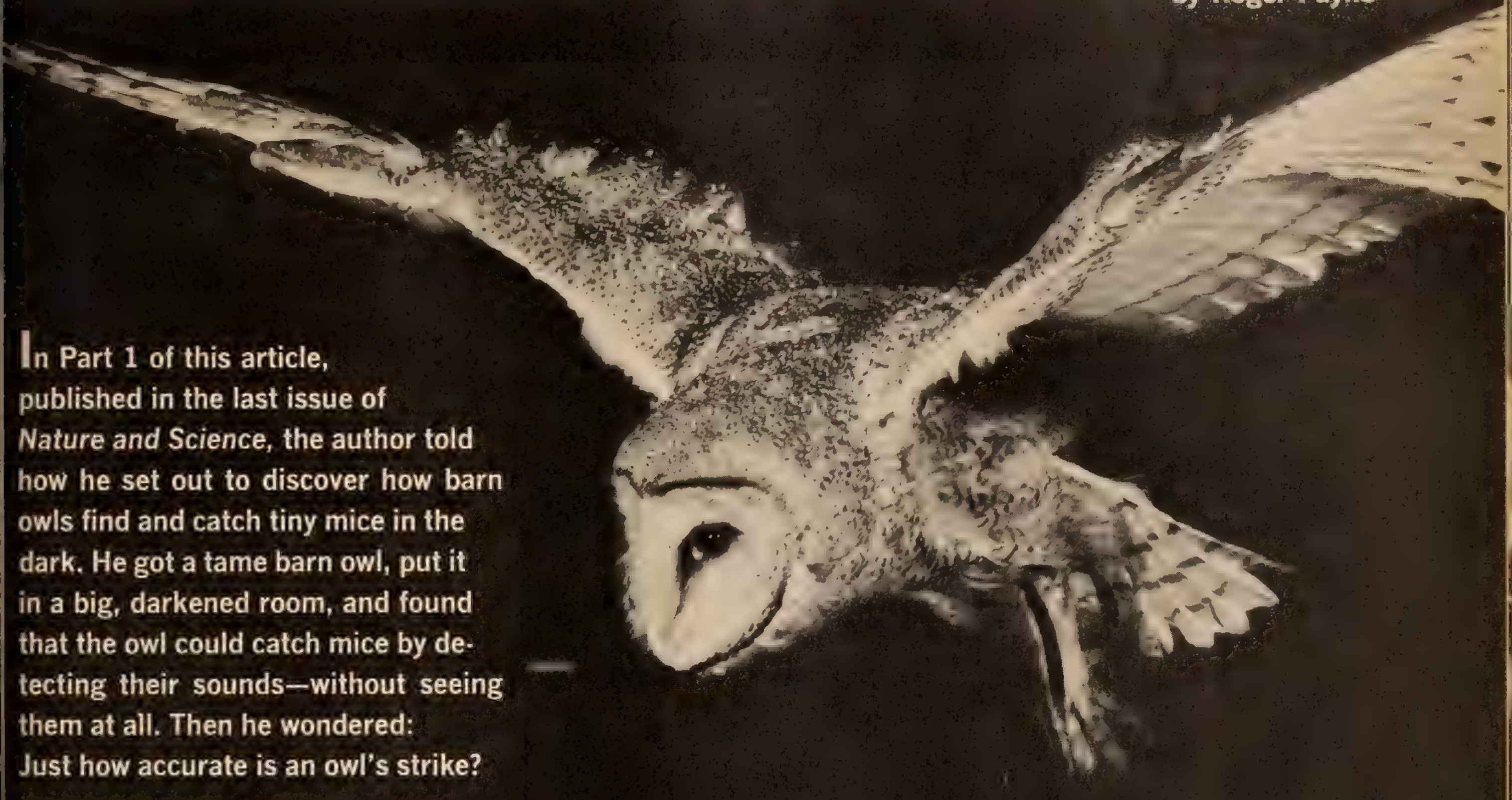
For science experts only: In the system of wheels and gears, Wheel B turns in the same direction as Gear A.

Can you do it? The drawing shows how to cut a cube into three equal pieces.



When an Owl Strikes

by Roger Payne



In Part 1 of this article, published in the last issue of *Nature and Science*, the author told how he set out to discover how barn owls find and catch tiny mice in the dark. He got a tame barn owl, put it in a big, darkened room, and found that the owl could catch mice by detecting their sounds—without seeing them at all. Then he wondered: Just how accurate is an owl's strike?

■ Whenever the barn owl attacked a mouse, I always turned on the lights as soon as I heard the sound of the owl striking. But I found that I was always looking in the wrong place when I switched on the light. The mouse was never where I thought it was, yet the owl seemed always to know where the mouse was. It missed rarely, and then only by inches. I was so impressed by the accuracy of the owl's hearing that I wanted to measure exactly how accurate it was.

Since I had no way of knowing just where a live mouse would be when the owl struck, I decided not to use live mice for targets in my accuracy measurements. Also, the dry leaves on the floor made it impossible for the owl to leave claw marks or any other sign showing *exactly* where it struck. I solved this problem by sweeping away all the leaves and covering the floor with sand.

Then I turned out the lights so the owl would not see what I was doing. I walked to about the middle of the room and put a dead mouse on the sand. The mouse had a leaf tied to its tail. It also had a long string tied to it. I took the end of the string and made my way through the dark to a small hideout I had built in one corner of the owl room. There I listened until I could tell that the owl was sitting calmly on its perch. Then I pulled gently on my end of the string, moving the mouse and the leaf. When the owl heard the sound of the leaf scraping on the sand, it left its perch and struck. I turned the lights on quickly.

I did this many times. If the owl missed, I would run to it before it had time to pounce on the dead mouse. Then I would make notes on both the position of the dead

(Continued on the next page)

This article was adapted from How Owls Hunt, *by Roger Payne. Copyright © 1966 by Educational Services Incorporated, Newton, Massachusetts. This booklet was written for the Elementary Science Study project of ESI, and will be published by the Webster Division of McGraw-Hill Book Company. ESS is supported by the National Science Foundation. Dr. Payne is an Assistant Professor at the Institute for Research in Animal Behavior, run jointly by The Rockefeller University and the New York Zoological Society.*

mouse and the place where the owl's feet had left marks on the sand.

Search for a Foolproof Test

Before long, I discovered that there were things wrong with this experiment. It was not a foolproof test of the owl's hearing accuracy. For one thing, the owl's feet hit the sand hard and spread it around. This made it impossible for me to find the *exact* place where the claws struck the sand. My measurement might be wrong by as much as one and a half inches, a distance almost as great as the length of a mouse's body.

Second, I could not be sure that the leaf had not changed its position and rustled a little when the owl was in flight. If it did, the noise would give the owl an extra clue. I knew this because a few times I had tried rustling the leaf on purpose while the owl was in flight. Whenever I did, the owl didn't miss the target—even when it had to fly the whole 40-foot length of the room. This meant that the owl could correct its aim while flying.

Finally, I had no way of knowing what kind of error I was measuring. Was the owl missing the target because it could not hear perfectly? Or because it could not fly perfectly in the dark? Or both? It seemed to me that it must be difficult for an owl to fly well in pitch darkness, just as it is for a person to keep his balance and walk in a straight line when he is blindfolded.

In order to get rid of these three weaknesses in the experiment, I decided to use a tiny loudspeaker for the owl to strike at. When I wanted the owl to strike, I broadcast through the speaker a tape recording of a mouse rustling leaves. On the perch, I put a switch which turned the recording off automatically when the owl left the perch. This meant that there was no chance of the owl getting extra sounds to guide it as it flew. On top of the speaker I put a dead mouse so that the owl would be rewarded each time it found the speaker correctly.

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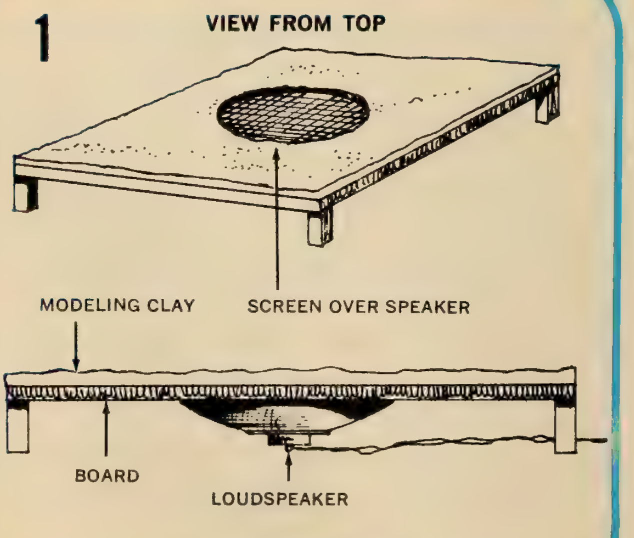

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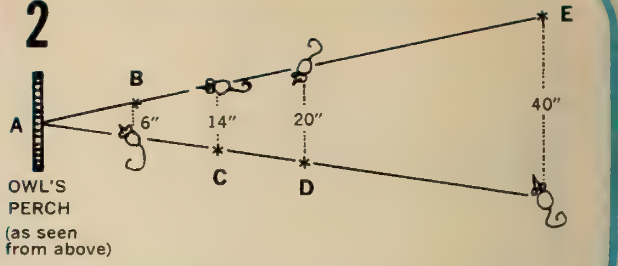

This drawing shows the distance an owl would be off target if it made an error of 20 degrees as it tried to catch mice farther and farther from its perch. Actually, the barn owl never made an error as big as one degree.

I mounted the speaker on a board covered with modeling clay except for one small hole above the speaker *(see Diagram 1)*. When the owl struck at the sound, it would dig its claws into the clay around the speaker hole. This would give me an accurate record of the landing place.

I left the light on during the experiment. The owl could then use its eyes, if it wanted to, for flying. Even with the light on, however, the owl couldn't see where the loudspeaker and the mouse were because the whole floor was evenly spread with leaves, and the mouse and the speaker were hidden under them. I also put up a screen between the owl and me so that the owl never saw me when I was hiding the loudspeaker.

How Might You Measure an Owl's Accuracy?

Every time the owl missed the speaker, I made notes on the exact position of the speaker and of the claw marks in the clay. My next problem was figuring out a way of describing the owl's accuracy. Suppose I said, "The owl never missed a mouse by more than one inch." Would this statement tell you whether the owl was a good shot or a bad shot?

If the owl was 100 feet away, a one-inch miss would show excellent aiming, but if the mouse was just a foot away, a one-inch miss would be very poor aiming. What I needed was a way for figuring out how much the owl would be likely to miss at *any* distance. So I decided to measure the owl's accuracy in *angles* rather than in inches.

Diagram 2 shows what I did. Suppose you are looking down at the floor of the owl room from the ceiling. Point A is where the owl sat on its perch when it was deciding where the mouse was. Points B, C, D, and E are where the owl struck on different flights (as I could tell from its claw marks). The picture of the mouse shows where the mouse sound really was. By drawing a line from the perch to the mouse, and another line from the perch to the claw marks at Point B, for example, I could make an angle that showed the number of degrees the owl was off target. By doing this every time the owl struck, I got an average measurement of its error in degrees.

As it turned out, the owl never made an error as large as one degree. An owl can locate a mouse by sound correctly within less than one degree to the left or right. By any standard, that is good aiming when you are talking about "setting your sights" by hearing.

What About Up-and-Down Aim?

Aiming to the left or right is not all an owl has to do to catch a mouse. The owl could have a perfect left-right aim and still overshoot the mouse if it aimed high. Or it could land short of the mouse if it aimed low.

Diagram 3 shows how I measured the accuracy of the owl's up-and-down aim. It is drawn as if you are looking sideways across the owl room. Point A is where the owl's ears were when it decided where the mouse was. Point B is where the owl struck the mouse, and the drawing of the mouse shows where the mouse sound really came from. Notice that the owl's up-and-down aim covers more ground than an error of one degree from side to side.

Even if the owl had ears that could aim up and down as accurately as they can right to left, it would still be harder for it to tell how far from the base of its perch a sound was than it would be for it to tell how far to one side it was. For example, even if the owl could locate the sound in an area only six inches wide, that area might be 10 inches long. However, when I put together my measurements of the owl's strikes, I discovered that its up-and-down aim is almost *twice* as good as its side-to-side aim. It can correctly locate the spot that a sound comes from within about one-half of a degree up and down!

Exactly how does this sort of accuracy help a barn owl to catch a mouse? At a distance of 20 feet, for instance, the owl should be able to pinpoint a sound to an area roughly three inches wide and six inches long. This happens to be the area covered by the spread-out claws of the owl added to the length of an average mouse. Thus, no matter where the mouse is in such an area, the owl should hit it with at least one *talon,* or claw, when it strikes. Thus my accuracy measurements showed that an

(Continued on the next page)

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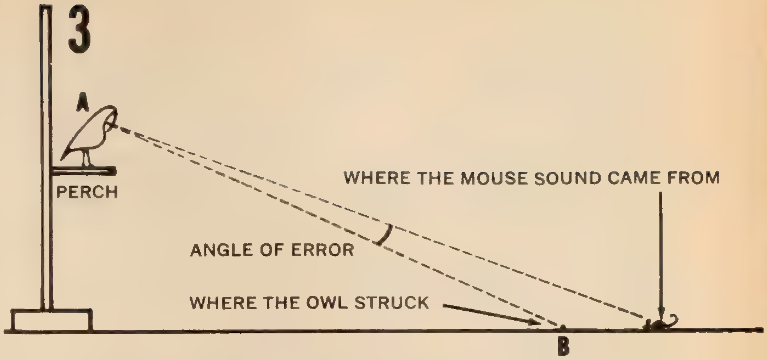
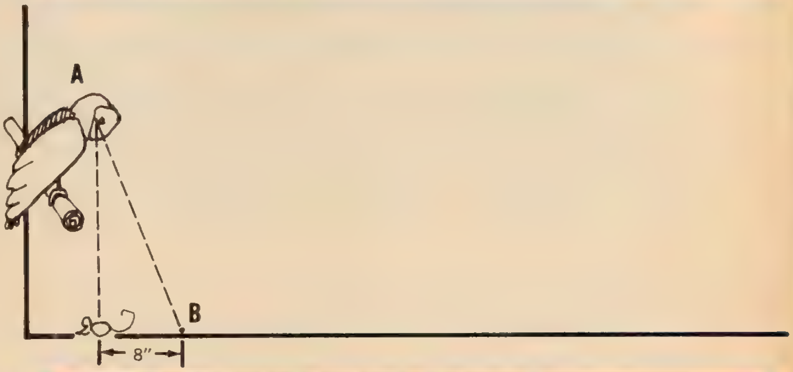
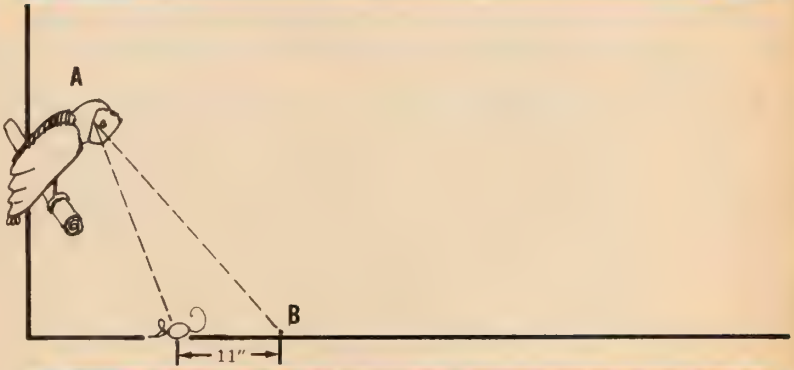
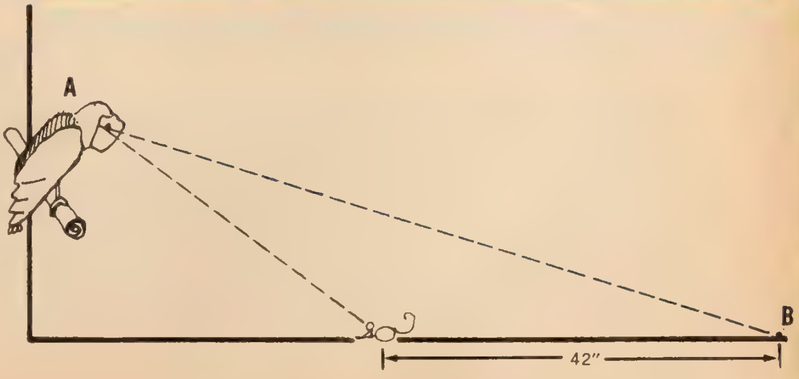


This side view of the "owl room" shows how the author measured a barn owl's up-and-down aim. The drawings below show how an owl's distance from a mouse affects its aim. The angle of error stays the same, but the size of the error increases with distance from the owl's perch.







The author found that the barn owl he studied did not try for a direct hit on a mouse unless the mouse was within 23 feet. A barn owl's hearing should enable it to catch a mouse every time within this distance.

When an Owl Strikes (continued)

owl should be able to catch a mouse every time if the mouse is 20 feet away or less. At greater distances it would miss quite often.

In the light of this, I was fascinated to see that beyond 23 feet an owl will not try for a direct hit. Instead, it flies down from its perch and lands softly on the floor, short of the place where the sound came from. It holds still for a few seconds, listening for more sounds, and then flies in for the strike. It does not try for a direct hit beyond the distance at which it is almost certain to get the mouse—23 feet.

Probably a barn owl's hearing accuracy is even better than I have given it credit for. But my method of testing accuracy had its problems. The only loudspeaker I could afford was very poor, so the mouse sounds were distorted. This almost surely led the owl to make errors.

Another Way To Test Accuracy

Because of this problem, I am now planning a completely different sort of experiment. I want to see how accurately the owl can locate a mouse without flying *at all*.

To do this, I will first have to train an owl to do something besides flying when it hears a recorded sound. This is not hard to do since an owl spends lots of time nibbling things. I have made some electric switches that turn on when nibbled. So all I have to do is wait for the owl to nibble a switch and then reward the owl with food.

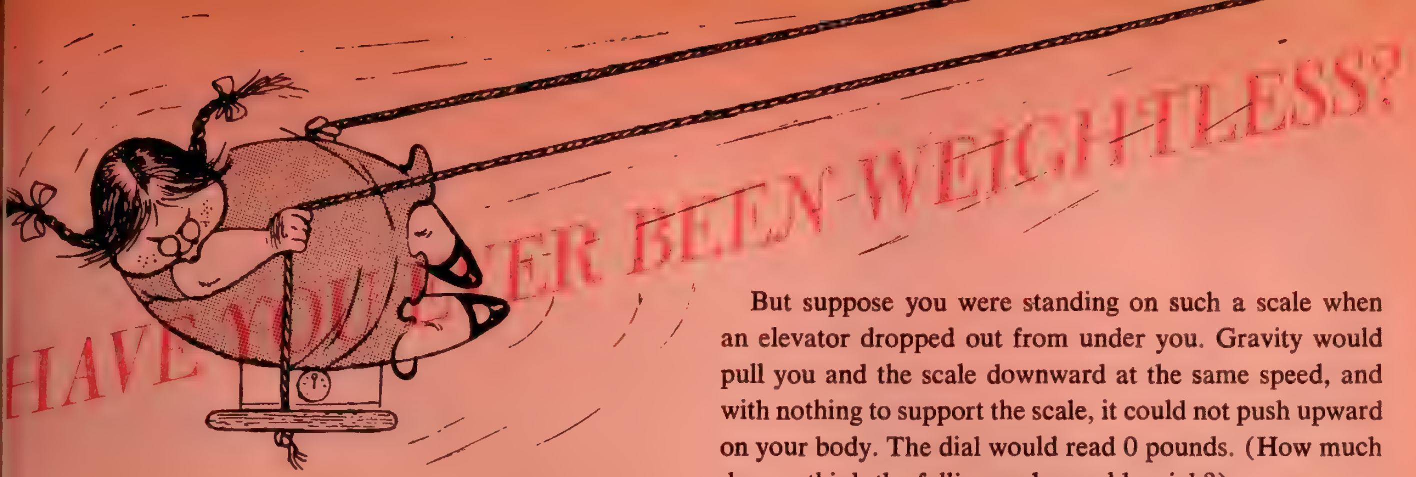
When the owl has learned to do this, I will train it to nibble the wood near its left foot when it hears the sound coming from its left side, and to nibble the wood near its right foot when it hears the sound coming from that side. Only when it nibbles near the correct foot will it get a food reward. As an owl gets used to earning its meal in this way, I will then begin to play the sounds closer and closer to a spot directly in line with the owl's line of sight. When the owl is unsure which piece of wood to nibble, it should make as many wrong nibbles as correct ones.

By gradually moving the sounds farther to either the left or the right (until the owl can again correctly locate the sound), I can draw an angle that shows at what point the owl stops "guessing" at the location of the sound. This angle will be the smallest angle within which an owl can locate a sound source accurately.

This experiment might be fun to try yourself. Have a friend blindfold you and then make clicking or tapping sounds to the left, right, and in front of you. Find out in what area you can no longer tell whether the sound is coming from the right or the left side ■

Just how does an owl grab a mouse when it strikes? In the next issue, the author tells how he tried to find out.

HAVE YOU EVER BEEN WEIGHTLESS?



■ You have probably heard or read about the feeling of weightlessness that astronauts have when they are orbiting the earth. And you have probably seen photographs of an astronaut moving around outside or inside his orbiting spacecraft without anything to hold him up, or *support* him. Do you think it is his weightlessness that enables him to move around without even a Mary Poppins umbrella for support?

A Swinging Way To Lose Weight

One way to find out is to think about some times when you have probably felt weightless. For example, when you were swinging high on a playground swing and, at the highest point in a swing, you felt for an instant as though you were hanging in midair. Or when you got the same feeling in an elevator that dropped suddenly.

At those instants, you felt weightless because your body was not pressing down on the swing seat or the floor of the elevator. In fact, you are weightless whenever your body is *falling*—whenever there is nothing supporting your body against the downward pull of the earth's gravity.

This is because *weight* is a measure of gravity's pull on the material that makes up your body. A bathroom scale measures your weight by measuring how much a spring has to push you upward to keep the pull of gravity from moving your body downward, that is, toward the center of the earth *(see "How It Works—Bathroom Scale,"* N&S, *November 14, 1966).*

But suppose you were standing on such a scale when an elevator dropped out from under you. Gravity would pull you and the scale downward at the same speed, and with nothing to support the scale, it could not push upward on your body. The dial would read 0 pounds. (How much do you think the falling scale would weigh?)

Falling Around the Earth

It takes a powerful rocket engine to push a spacecraft 50 miles or so from the earth's surface against the pull of gravity. And when the rocket has dropped off, there is nothing supporting the craft against the pull of gravity—not even the air, which supports a bird or airplane in the earth's atmosphere *(see "On the Wing," in this issue).*

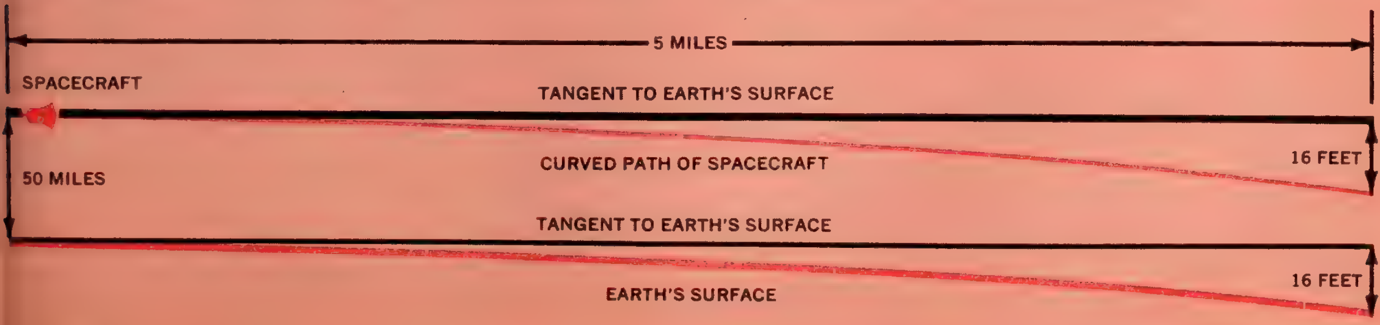
But before the rocket drops off, it shoots the craft off in a path that is *tangent* to the earth's surface *(see diagram).* In one second the craft travels five miles in this direction and is pulled 16 feet toward the center of the earth by gravity. As a result, it follows a path that is curved just like the earth's surface, so it stays at the same distance from the earth. It is weightless because it is falling, but it falls *around* the earth instead of *onto* it. Only when the astronauts fire their retro-rockets to slow the craft down does it fall back to the earth and to "weightiness" ■

How Much Would You Weigh on the Moon?

The moon is made of so much less material than the earth is made of that the moon's gravitational pull is only about 16 per cent as strong as the earth's. Can you figure out how much you would weigh on the moon?

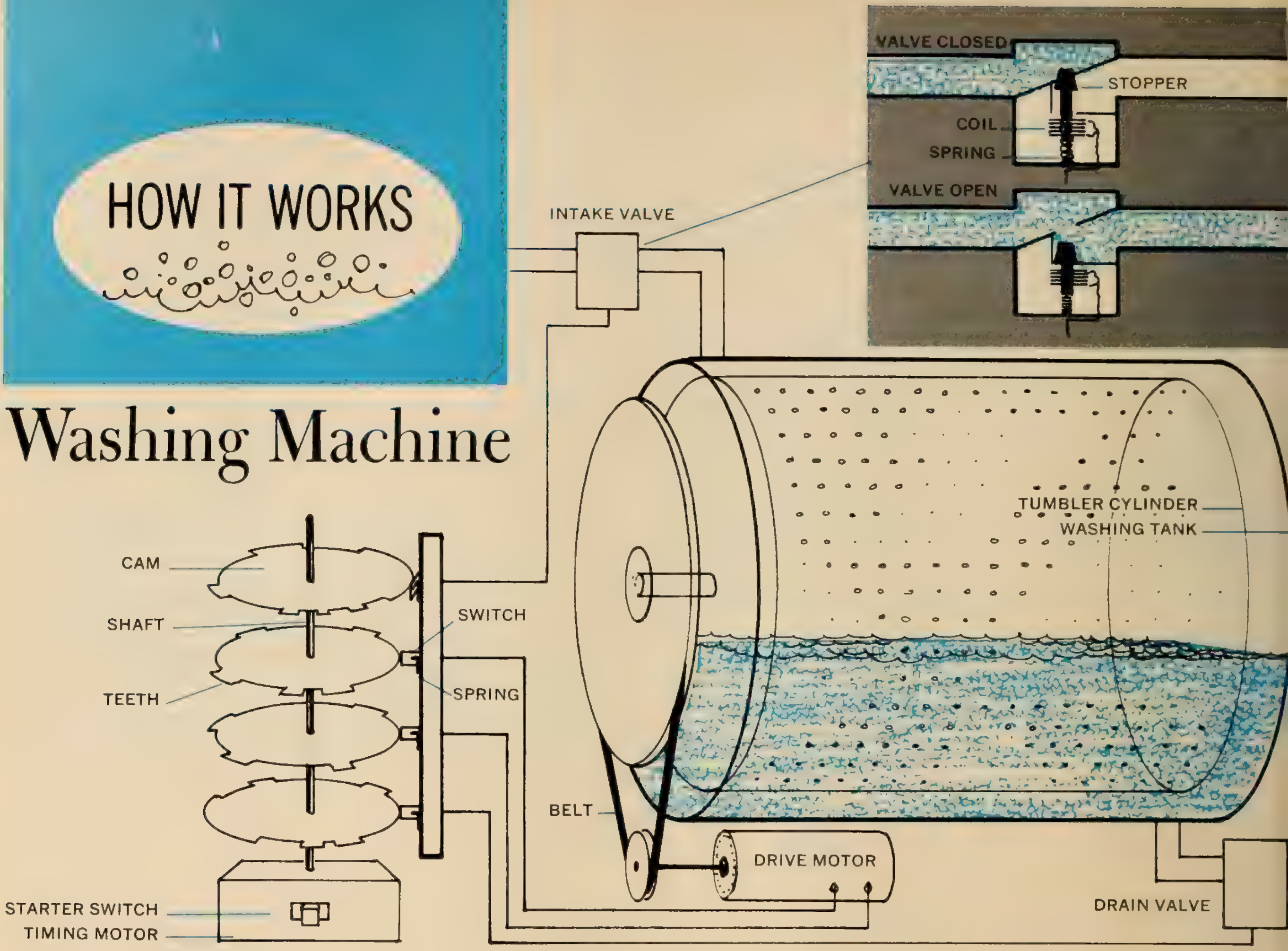
If you were in a spacecraft between the earth and Mars, would you be weightless? Can you explain why?

A spacecraft stays 50 miles away from the earth by moving five miles "ahead" as it falls 16 feet each second. The craft follows a path that is curved the same as the earth's surface, so it falls around the earth instead of onto it.


5 MILES
SPACECRAFT
TANGENT TO EARTH'S SURFACE
CURVED PATH OF SPACECRAFT
16 FEET
50 MILES
TANGENT TO EARTH'S SURFACE
16 FEET
EARTH'S SURFACE

HOW IT WORKS

Washing Machine



■ An automatic washing machine seems to be doing many different things as it washes and rinses your clothes, then spins most of the water out of them. But during the half hour or so it takes to launder your clothes, only four *different* things happen inside the washer.

The four different "happenings," or *operations,* are these: 1. Water flows into the washing tank. 2. A cylinder inside the washing tank turns slowly, tumbling the clothes about in the water. (In a machine that you load from the top, the clothes are stirred by a center post that turns back and forth.) 3. Water drains out of the washer. 4. The cylinder spins rapidly to throw water out of the clothes.

Some of these operations take longer than others, and sometimes several are going on at the same time. Each operation is started or stopped by a switch in the *timer* unit *(see diagram),* which programs the "happenings."

How the Timer Directs the Operations

When you press the starter switch (or push a quarter into a coin-operated washer), an electric current starts the *timing motor.* This motor is something like an electric clock motor, and it turns a long shaft very slowly. On the shaft are four *cams,* or discs with squared-off "teeth" spaced unevenly around their edges. Beside each cam is a switch that controls one of the machine's four operations.

As the cams begin to turn, a tooth on the first cam pushes down the switch beneath the cam, sending an electric current through a wire coil in the *intake valve (see diagram).* The current makes the wire coil an electromagnet, and it pulls the metal valve *stopper* into the coil, opening the valve to let water into the washer.

When the cam tooth has turned past the switch, a spring pushes the switch up, stopping the flow of current through the wire coil. Since the coil is no longer pulling on the stopper, a spring pushes the stopper back into the valve opening, closing off the flow of water.

Then the second cam switches on the *drive motor* at slow speed, and a belt that is pulled by the motor turns the tumbling cylinder just fast enough to keep the clothes moving around in the water. After a few minutes, the second cam releases the slow-speed motor switch, and the third cam pushes down the high-speed motor switch. At the same time, the fourth cam opens the drain valve, so that the soapy water can drain out of the machine as it flies out of the rapidly spinning clothes.

The timer then puts the machine through the same series of operations (though timed differently than before) to rinse the clothes and get them ready for drying ■

Using This Issue...
(continued from page 2T)

may not rank with such "accidental" discoveries as X rays and penicillin, but nevertheless it nicely illustrates the above quote. Your pupils might enjoy investigating other "accidental" scientific discoveries.

Some of your pupils may wonder how the biologists tested the stickiness of spider webs on different kinds of insect wings. The diagram on this page shows how it was done, using a soda straw balance. *(To make an even simpler soda straw balance, see "How Much Water Do You Eat?",* N&S, *Feb. 15, 1965.)*

In recent years, biologists have discovered that some kinds of moths are able to escape bats by detecting their ultrasonic chirps. On hearing a distant bat, the moths turn and fly directly away. If the bat's sounds are close, the moth usually goes into a dive or loop that carries it toward the ground and safety. Thus the sensitive ears of moths are another adaptation that enables them to escape predators.

The "detachable" tails of some lizards are an adaptation for escape that is somewhat analogous to the scales on a moth's wings. The tails are brightly colored, while the rest of the lizard's body is plain. When a predator seizes the tail, it breaks off, enabling the lizard to escape; later a new tail grows. In the case of moth scales, no new scales grow.

Reference

- *Spiders*, by Verne N. Rockcastle, is a new 32-page Cornell Science Leaflet, available for 25 cents from Cornell Science Leaflets, Stone Hall, Cornell University, Ithaca, New York. It includes lists of activities and helpful references.

On the Wing

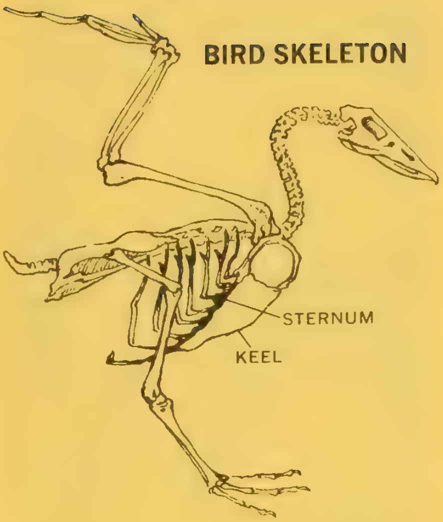
In spite of what many people believe, the flapping of a bird's wing is not enough to get the bird into the air. Like an airplane, a bird must have a wing of a definite shape—one that is curved outward on top and inward on the bottom. This shape is called an *airfoil.*

The side views of a bird and an airplane in the chart illustrate how air rushing over the airfoil shape produces *lift.* Air is a fluid, and the faster a fluid flows, the less strongly it presses against a pipe or whatever it is flowing through, or over.

Activities

- Have the class examine a whole, uncooked chicken (or other bird), and a chicken skeleton (or bones left from a meal). If you can get a chicken or other bird with feathers still attached, you can compare the different kinds of feathers and see how flexible the primary (flight) feathers are. On a bird skeleton, point out the large breastbone, or *sternum (see diagram).* Most birds have a large keel on the sternum, where the big pectoral muscles attach. The size of the keel is a fair index of wing strength. Non-flying birds, such as the ostrich, have no keel. Penguins, though flightless, use their wings for swimming, and so have keels.

Point out to your class that the big pectoral muscles of domestic birds such as chickens and turkeys are light-colored because there are few blood vessels within the muscles. Birds which are more active flyers have darker pectoral muscles, the color being due to the blood vessels that nourish the muscles.



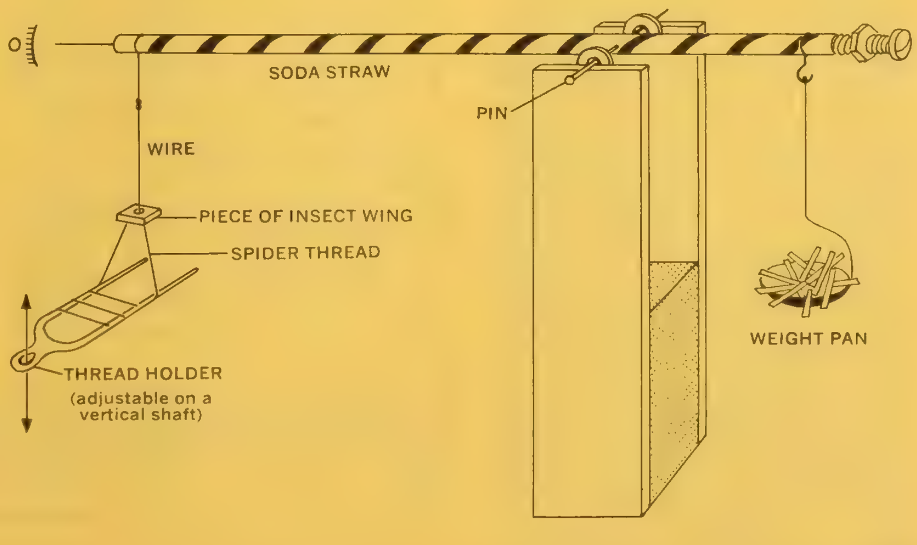
- Examine bird feathers with a hand lens or a low-power microscope. Look for the tiny hooked *barbules* that line the surface of the *barbs* branching from the feather's main shaft.

The barbules of a feather lock together, forming an unbroken surface. If you separate two barbs with a pencil or other object, they can be rejoined by stroking the feather, which lets the barbules hook onto each other. This is what a bird does as it preens itself with its bill.

Topics for Classroom Discussion

- *Why can't man fly under his own power?* Humans are adapted for erect travel on earth. Though men have made strong, lightweight artificial

(Continued on page 4T)



This modified soda straw balance was used to measure the stickiness of spider webs to the wings of different kinds of insects. A piece of insect wing was brought in contact with a single strand of spider thread, held across two prongs of a wire holder. Then small wire weights were added one at a time to the pan on the opposite side of the balance. As weights were added, the arms of the balance were kept level by moving the thread-holder downward along the shaft that held it. When the spider thread broke from the insect wing, the load on the pan gave a measure of the sticky bond between the two.

Using This Issue . . .
(continued from page 3T)

wings, they haven't the massive chest muscles needed to lift their bodies into the air. Man's center of gravity is in the hip region; in birds it is centered near the chest. Bird bones are hollow and lightweight; man's are heavy and make up a big share of his weight. Bird hearts are relatively larger and beat faster than mammalian hearts. These are a few of the ways in which birds and men differ, and why humans must depend on machines for flight.

- *How is swimming like flying?* Compare the downstroke and upstroke arrangements of bird feathers *(see diagram in chart)* with your strokes in swimming. Why should your fingers be close together for a powerful downstroke? How can you bring up your arm and hand for the next downstroke without losing much momentum? Notice how a bird's flight feathers and wing are arranged to solve this problem.

References

- *Biology of Birds,* by Wesley E. Lanyon, The Natural History Press, Garden City, N.Y., 1963, $1.25 (paper).
- *The Birds,* by Roger Tory Peterson, LIFE Nature Library, Time Inc., New York, 1963, $3.95.
- *The Flight of Birds,* by John H. Storer, Cranbrook Institute of Science, Bloomfield Hills, Mich., 1948, $2.50.
- *Flight,* by H. G. Stever and James J. Haggerty, LIFE Science Library, Time Inc., New York, 1965, $3.95.

When an Owl Strikes

In this second of three articles, Dr. Roger Payne tells how he tried to determine the accuracy of an owl's hearing. Point out to your pupils the importance of measuring the owl's accuracy in *angles,* not in feet or inches. The diagrams with the article show how the linear size of errors increases with distance while the angle of error stays the same.

Also point out to your pupils that the author wasn't able to experiment continuously with the owls he studied. Since an owl was rewarded with food as the experiments went on, the author had to stop the tests when the owl was no longer hungry; otherwise he couldn't be sure that the owl was "trying" as well as it could.

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◄ N & S REVIEWS ►

Recent Natural History Books for Your Pupils

by Barbara Neill

A Book of Snakes, by Dorothy Childs Hogner (Thomas Y. Crowell Co., 102 pp., $3.50), is suitable for 9- to 11-year-olds and is a good introduction to snakes. The first 16 pages are devoted to such things as a snake's teeth, internal structure, what snakes eat, etc. The rest of the book is devoted to descriptions of species of North American snakes. Since similar information plus colored illustrations is available in field guides, an expansion of the first section might have been more useful.

No Holidays for Honeybees, by Mervyn Kaufman (Coward-McCann, 64 pp., $2.86). This book tells in simple fashion the life story of honeybees, how and why they swarm, their division of labor, how honey is made, etc. Reference is also made to the work of the beekeeper and some of the terms he uses. The illustrations are an excellent complement to the text. The jacket suggests this book for 7- to 11-year-olds, but second and third graders would certainly need to have it read to them. It contains a glossary and an index.

The Big One, by Walter J. Wilwerding (G. P. Putnam's Sons, 94 pp., $3.64). The title story, about an elephant in danger of his life from ivory poachers, is one of 12 stories about African animals. The author is a noted animal artist who has made many trips to Africa. He conveys well the sights, smells, sounds, and excitement of Africa. Especially the excitement. Animals show anxiety, fear, rage, and anger, and they are hiding, running, fighting, or killing much of the time. One longs for a few quiet paragraphs. However, this book has much interesting information on such obscure animals as the African bush cat, the hyrax, zoril, and genet. And the illustrations are outstanding.

The Bug Club Book, by Gladys Conklin (Holiday House, 96 pp., $2.95), is not a book for "tiny tots," as the title may imply. It is for 8- to 12-year-olds who seriously want to know more about insects. Not only is there a good deal of general information but there are directions for raising caterpillars, keeping water insects, mounting insects, and lots of other activities for a lively young insect collector. Since the author has worked with children in a "bug club," she knows what appeals to them and she writes in an appropriately informal manner.

Caddis Insects, by Ross E. Hutchins (Dodd, Mead and Co., 80 pp., $3.25). The caddisfly seems an unlikely subject for a book, especially one to be described as fascinating, yet this one is just that. One need not be an entomologist to wonder at the skill shown by the larvae. These water dwellers construct beautiful cases of pebbles, sand, twigs, bark, or plant fibers which protect them in their immature form. Each species specializes in one type of case, which may be cyl-

(Continued on page 3T)

Barbara Neill is a Senior Instructor in the Education Department of The American Museum of Natural History in New York.

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● In the Land of Bikpela Rat Moa
A mammalogist tells how he prepared for a plant and animal-collecting expedition to the wilds of New Guinea.

Testing the Strength of Paper
Your pupils can learn about tensile and compression strength by using a bathroom scale and a homemade spring scale to test paper.

● Rivers in the Sea
This WALL CHART shows the oceans' major currents and what makes them flow.

● Cabbage Chemistry
Using red cabbage juice as an indicator, your pupils can detect acids and bases in household substances.

Brain-Booster Contest Winners

● Catching Mice in the Dark
A biologist discovers how an owl, in total darkness, traps its prey between its claws.

IN THE NEXT ISSUE

A SCIENCE WORKSHOP investigation into bouncing balls . . . Insects to look for on the spring snow . . . Expedition to New Guinea, Part 2 . . . The search for a way to keep barnacles off ships' bottoms.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Expedition

Going on expeditions, collecting specimens, and bringing them back for study was once the main work of biologists. These are the first steps that have to be taken when scientists seek to learn about the life of an unknown area. Usually there isn't time to stay long and to study the living animals and plants in their natural surroundings. So the main objectives of an expedition are to sample different habitats, to find what organisms live in each habitat, and to take specimens back for further study. The author of this article, Hobart Van Deusen, hopes that the scientists of the Archbold Expeditions may soon begin studies of living mammals of New Guinea in their natural environment.

To compare the preparations for this expedition with those of a botanical expedition, see "Exploring in the Rain Forest," *N&S,* Nov. 2 and Nov. 16, 1964.

Topics for Class Discussion

- *What is Pidgin English?* A pidgin language is a simplified speech used for communication between people who speak different languages. Pidgin languages are also called "trade" languages. In the case of Pidgin English, the language has become a native language, used among people of the Territory of New Guinea. Your pupils may enjoy pronouncing some of the words and reading about their origins.

- *Why does New Guinea have such a great variety of plants and animals?* In the tropics, communities of plants and animals are much more complex and varied than in temperate zones. This is mostly due to the warm climate, with abundant rainfall and a long growing season. In New Guinea, the rugged terrain also encourages a variety of life. As you climb a mountain, the climate changes with altitude. The change is similar to one that occurs when you travel northward in the Northern Hemisphere (or southward in the Southern Hemisphere). Thus, on the top of New Guinea's mountains, you find alpine habitats.

Rivers in the Sea

As your pupils study the large map (surface currents) on this WALL CHART, point out that the steady winds that blow toward the equator–from the northeast in the Northern Hemisphere, and from the southeast in the Southern Hemisphere–make the surface layers of water move across the Atlantic and Pacific Oceans from east to west. These great westward-moving currents cause many complex movements of the water in other parts of the oceans.

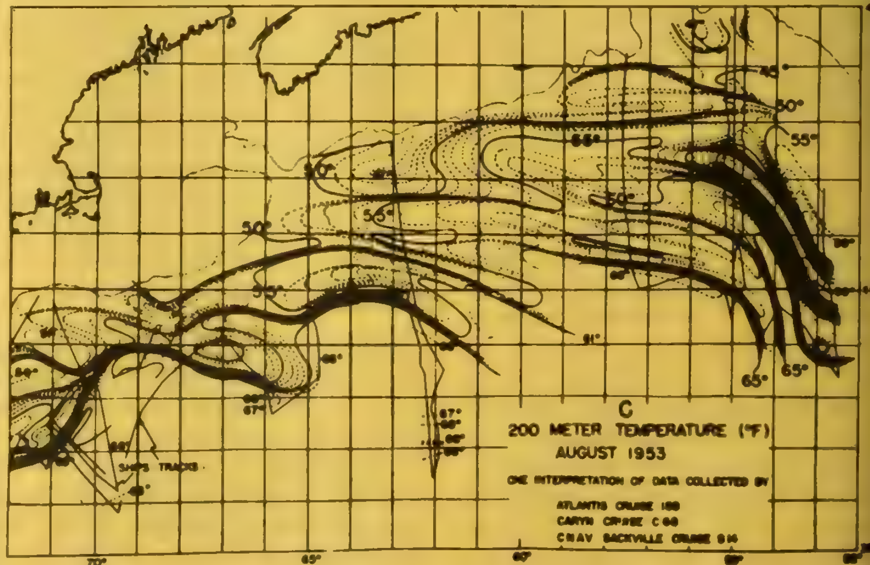
When the North and South Equatorial currents approach the barriers of the continents they are deflected and swing toward the south in the Southern Hemisphere and toward the north in the Northern Hemisphere.

Have your pupils make a current by blowing gently across the top of a pan of water. (A bit of talcum powder dropped on the water where the "wind" starts will make the current easier to follow.) The current moves across the pan to the opposite edge, where it swirls around and begins moving back along the edge of the pan, replacing the water that was blown away along the "equator" of the pan. The Gulf Stream follows a similar course when it reaches North America.

The small map shows how colder water from the Arctic and Antarctic oceans flows southward and northward forming currents deep in the sea. Your pupils can make such underwater currents by pouring warm wate into a large clear plastic or glass bowl or aquarium until it is about ¾ full. Fill a plastic bag with cold water and dissolve two or three drops of ink i the water. Hang the bag from the sid of the container so that at least hal of the bag is under water.

When the water in the container has

(Continued on page 3T)


SHIPS TRACKS
50°
55°
56°
65°
70°
C
200 METER TEMPERATURE (°F)
AUGUST 1953
ONE INTERPRETATION OF DATA COLLECTED BY

The map in "Rivers in the Sea" shows the Gulf stream and other major currents as broad, smooth-sided currents for easier comprehension. Point out to your pupils that each is actually a series of currents that overlap and meander like a river, as shown in this chart of the Gulf Stream made in 1953 by the Woods Hole Oceanographic Institution in Woods Hole, Massachusetts.

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ature
nd science

VOL. 4 NO. 11 / FEBRUARY 27, 1967

Get ready for
an expedition to . . .
THE LAND OF
BIKPELA RAT MOA
see page 2

WHICH KIND
OF PAPER TOWEL
IS THE
STRONGEST?
see page 6
Testing the Strength of Paper

nature and science

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In the lan

Part 1

by Hobart M. Van Deusen

What kinds of animals and plants live in
rugged mountains of the Huon Peninsula of
Guinea? In this first part of a two-part artic
biologist tells how he planned an expeditio
find out.

■ A cyclone named Henrietta...a bush pilot lookin
a tiny landing strip in a jumble of limestone ridg
swaying bamboo bridges stretched over mountain
rents...a meal of python steaks...and drums throb
in the night! Does this sound like a James Bond advent
Actually, it is simply a fairly normal chain of even
the lives of two mammal collectors in the tropics. H
then, is the story of the American Museum's most re
expedition (in 1964) to the largest tropical island in
world—New Guinea.

The expedition had its beginning some time ago
1959. It was a beautiful late autumn day in June (the
sons are reversed in New Guinea, since it is below
equator). On that day, I stood on the peak of M
Wilhelm, 15,000 feet above the north coast of New Gui
I could look out across the valley formed by the Ramu
Markham Rivers to the massive blue bulk of the
Saruwaged Mountains on the Huon Peninsula *(see m*
We had been collecting mammals and studying plant
many weeks in the great chain of mountains that make
the 1,500 mile-long backbone of New Guinea.

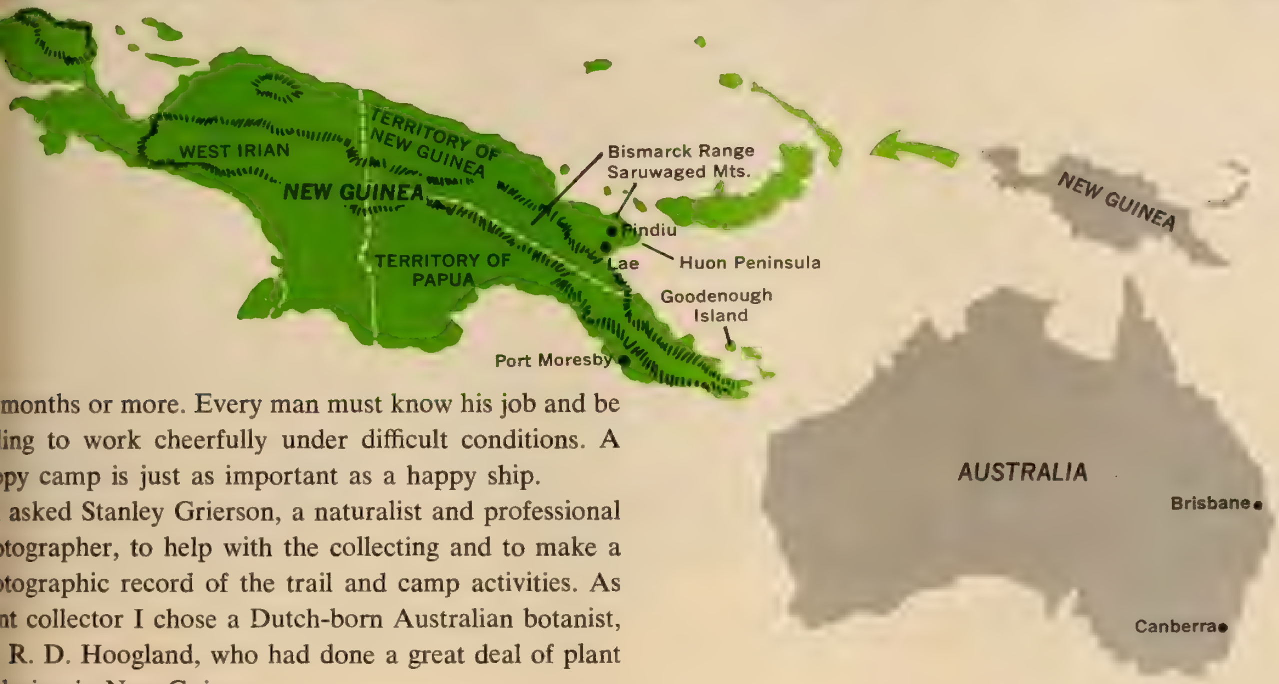
Right then and there I decided that if I ever retu
to New Guinea, I would climb the remote peaks of
Saruwaged Mountains. I wondered what plants and
mals lived there. I wanted to study the differences betw
the animal species we had collected in the Bismarck R
(see map) and those animals living in the mountains o
Huon Peninsula. Thus, in 1959 I began making plans
an expedition in 1964.

Choosing a Team for the Expedition

Choosing a team is the most important job in se
up any expedition, especially one that stays in the fiel

*Mr. Van Deusen is Assistant Curator of the Archbold Collec
Department of Mammalogy, The American Museum of Na
History.*

f BIKPELA RAT MOA



months or more. Every man must know his job and be ing to work cheerfully under difficult conditions. A py camp is just as important as a happy ship.

asked Stanley Grierson, a naturalist and professional tographer, to help with the collecting and to make a tographic record of the trail and camp activities. As nt collector I chose a Dutch-born Australian botanist, R. D. Hoogland, who had done a great deal of plant loring in New Guinea.

PIDGIN ENGLISH

...is a language of over 1,500 words, and from them you can translate at least 6,000 English words. The language comes from mixing Melanesian dialects and English. Many of the words have lost their original meaning and are pronounced differently. In the Territory of New Guinea *(see map)*, Pidgin English was a natural outgrowth of contact between the people of New Guinea and English-speaking traders and patrol officers. Pidgin English is a native language, used more among the people of New Guinea than between them and English-speaking people.

Here are a few Pidgin English words and their English meanings:

English	**Pidgin English**
snake	snek
worm	liklik snek *(meaning "little snake")*
expedition leader	nambawan *(meaning "number one")*
botanist	didiman *(one of the first botanists to explore the Territory of New Guinea was a German named Dittemann; now all plant collectors are called "didiman")*
call, yell	singaut *(meaning "sing out")*
wash	waswas
sea cow	bulmakau bolong solwara *(meaning "cow that lives in salt water")*
giant rat	bikpela rat moa *("bikpela" means "big"; "moa" means "very")*

Any collector who ventures into the rugged mountains of New Guinea needs a pair of strong legs. Roads are very few and far between. New Guinea is dotted with small air strips, but it often takes days of hard walking after leaving the air strip to reach camp. All camping gear, tents, collecting supplies, and food must be backpacked over the slippery mountain trails.

These conditions make it very important to hire a dependable man to recruit people to carry our gear from one campsite to another, to bargain for native food supplies, to make and break camp, and to help with the collecting. In this case, such a man also had to be able to be understood by the people of the Huon Peninsula. New Guinea, because of its mountains and many isolated valleys, has an incredible number of local languages—nearly 700 at latest count! Fortunately, in almost every village of the Huon Peninsula, there is someone who knows how to speak the delightful "shorthand" language—Pidgin English *(see box)*. So my first requirement for an expedition "manager" was a man who could speak "pidgin."

Again I was fortunate. The wife of a coffee plantation owner wrote that her younger brother, Ken MacGowan, was looking for such a job. Ken was born in New Guinea, and spoke fluent "pidgin." In addition, as I soon learned in the field, Ken was just as skilled at handling animals as he was at organizing camps and carrier lines.

Next, I had to find a dependable cook. Some say that

(Continued on the next page)

The author, Hobart Van Deusen (kneeling in foreground), is shown with other biologists from The American Museum of Natural History as they get equipment ready and pack it for an expedition to New Guinea.

In the Land of Bikpela Rat Moa (continued)

a good cook is the most important person on an expedition! Fortunately, finding a cook was no problem. On three earlier trips our cook had been a man named Kim, a Papuan from Goodenough Island off the east end of New Guinea. Kim, an adventurer at heart and the best camp cook I have ever known, was delighted to join our expedition. Our roster was now complete except for some men to help Ru Hoogland collect plants and to help me collect mammals. These men would be hired later, when we reached the Huon Peninsula.

Unlocking New Guinea's Secrets

Early in the 1930s Richard Archbold, a Research Associate of The American Museum of Natural History in New York City, was looking over the world for a challenging area for biologists to explore. New Guinea was a natural choice. This tropical island had been discovered centuries earlier, but its rugged interior was still almost unknown. The island gave promise of having the richest plant life in the world. Also, birds of paradise, giant rats, and strange *marsupials (see "On the Trail of Wyulda,"* N&S, *Dec. 19, 1966)* were known to live there. But next to nothing was known about their lives or exactly where they lived.

Archbold's interest in New Guinea led to three history-making expeditions during the 1930s. But then World War II interrupted. After the war, Dr. Leonard J. Brass, botanist on the Archbold Expeditions, organized a 1948 trip to northeastern Australia and then he led expeditions to New Guinea in 1953, 1956, and 1959.

You may ask, "Why a seventh expedition to the *same* island?" New Guinea is no "ordinary" island. It is over 315,000 square miles in area (more than Texas and New York combined). It is far more mountainous than California. On any one trip (even though it lasts a year) we can study carefully only a few square miles of country. To make each study worthwhile, we try to establish camps in several different kinds of country, or *habitats*—from low-lying coastal rain forest up through oak, beech, "mossy," and sub-alpine forests to alpine grasslands in the high mountains. As we go from one habitat to another, we find changes in the communities of plants and animals living in them.

There are many reasons for such studies. Man's curiosity knows no bounds. Scientists from places such as the American Museum extend this curiosity into the world about us. Science, after all, is simply organized curiosity. It is because of this desire to know our planet that we go on expeditions.

There are, however, other reasons for expeditions to remote areas like New Guinea. One reason is the study of diseases. The tiny parasites (such as lice, mites, ticks, and fleas) that live on animals may be carriers of disease. So we collect these parasites from the animals that we catch and preserve for the Museum's study collections. The parasites can then be studied by *medical entomologists*—

scientists who study insects and other small animals that carry disease. In case of an outbreak of disease, their findings will help to identify the disease carriers.

Another practical reason for our expedition was to collect samples of plants that might be sources of medicines. We also collected wood samples from trees. The tropical forests, with their many tree species, will one day supply a wood-hungry world with many useful woods. Even today some of the finest plywood ever made is exported from New Guinea.

Getting Equipment Ready

Getting ready for an expedition, especially mammal collecting, is an easy matter. No two expeditions are ever the same, but you simply have to remember that the equipment should be kept to the essentials ("What do I really need?"), and it should be light and easily carried. Everything is packed into plywood boxes with reinforced ends and canvas tops. Such boxes are ideal for storage and travel in the field. Into these boxes we put such things as tents, clothing, traps,and other collecting gear.

Our food supplies would be bought in New Guinea. Trading stores in the larger towns carry all the needed staples such as rice, flour, salt, sugar, tea, canned corned beef, jam, and powdered milk and eggs. On the Huon Peninsula we were often able to buy fresh fruit and vegetables. The native women thought nothing of walking for several hours to sell us their loads of local foods.

Getting and packing supplies for plant-collecting was a more complicated story. A botanist needs portable drying ovens, kerosene pressure lamps, drums of kerosene, plant presses, bales of newspapers, special blotting paper, straps, chemicals for preserving flowers, axes, saws, aluminum carrying boxes, canvas bags, and many other items.

For actually getting the mammals, we needed traps of several kinds, bait (raisins, peanut butter, fat bacon, and rolled oats), mist nets (nets of fine silk or nylon mesh for collecting bats), shotguns, and ammunition.

To prepare and preserve the skins and skulls of the mammals we collected, we packed cotton, needles and thread, labels, chemicals, scalpels, scissors, drying boards, pins, and wire. We also had small bottles of alcohol for preserving parasites. Finally, we packed medical supplies, especially drugs to combat malaria *(see "Men, Mosquitoes, and Malaria,"* N&S, *Jan. 9, 1967).*

In the Tropics Again

Ru Hoogland shipped the plant collecting gear from Canberra, Australia. We sent the remaining supplies by freighter in December 1963 from New York for the 10,000 mile trip to Brisbane, Australia. From there they would be shipped to Lae, New Guinea, which was to be our base *(see map).* We planned to assemble in Lae in April, 1964, buy our food supplies, and get our gear ready to be flown to the village of Pindiu in the heart of the Huon Peninsula.

Stan Grierson and I sailed from New York by freighter early in March. The only event that interrupted the long voyage across the Pacific was our meeting with cyclone Henrietta. It was the largest of all recorded cyclones off the eastern Australian coast. Our ship's captain decided to steam at full speed across the southerly course of the slowly advancing cyclone and run for the Queensland coast.

After three days of battering seas and shrill winds, we woke to the normal sounds of a ship at sea and the welcome sight of the Glasshouse Mountains that rise abruptly from the flat plains north of Brisbane. A few hours later we docked at our berth on the Brisbane River.

This white-eared giant rat is held by Ken MacGowan, who was hired as "manager" of the expedition. In the Pidgin English language of New Guinea, giant rats are called "bikpela rat moa."

That night we flew north along the Barrier Reef and then over the Coral Sea, landing in Port Moresby, New Guinea, just at sunrise. After a day of making official calls, we flew over the Owen Stanley Range to Lae at the head of the Huon Gulf on the north coast of New Guinea. The long months of preparation were over, and we could see the high peaks of the Saruwageds looming behind Lae as our plane began to land.

Old friends, familiar sights—settling in at Lae had all the feeling of "coming home." The high humidity, the sudden showers, the smell of decaying vegetation mixed with the salt breezes off the Gulf, the nightly chorus of frogs in the Botanic Gardens, the geckos (a kind of lizard) on the ceiling chasing moths near every light—yes, I was surely in the tropics again! ■

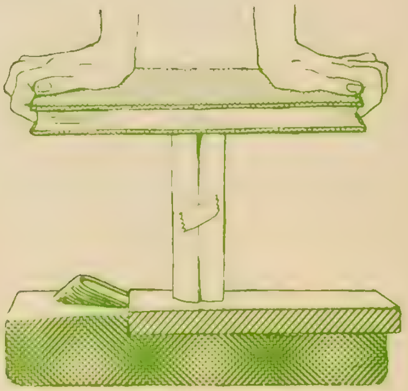
In the next issue of Nature and Science, *the author describes the adventures of the Archbold Expedition as the scientists collect animals and plants in the rugged New Guinea mountains, explore caves, and eat python steaks.*

TESTING THE STRENGT

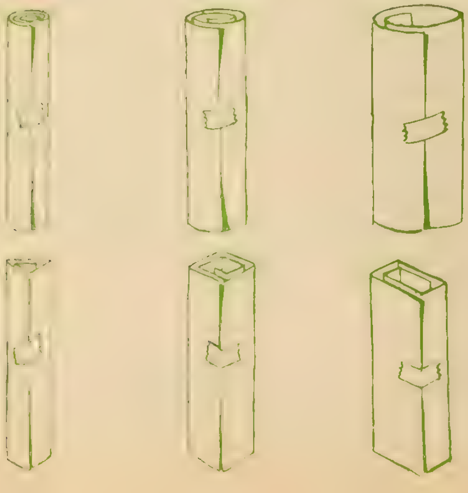
Which kind of paper towels are the strongest? How much weight will a paper tube support? Here's how to use a bathroom scale, ruler, rubber band, paper clips, and sticky tape to find out.

■ To find out whether a material is strong enough to support a building or a bridge, engineers test its *compression strength*—the amount of weight that can push on the material without bending or breaking it.

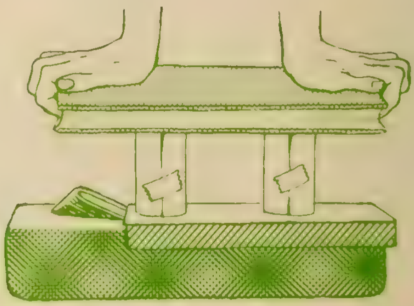
You can use your bathroom scale to measure the compression strength of paper tubes. Roll up a sheet of typing paper the long way and tape it in the middle. Then stand it on a bathroom scale. Now push straight down on top of the paper tube with a stiff book. How hard can you push before the paper column crumples?



Test the compression strength of different-shaped paper tubes. Is a skinny tube stronger than a fat one? Is a tube made from two sheets of paper twice as strong as one made with a single sheet? Try making some tubes of other shapes *(see diagram)*. How do they compare in strength with round tubes?



Cut several tubes in half. Can you push harder on half a tube? Can you push twice as hard on two half-tubes?



Testing Another Kind of Strength

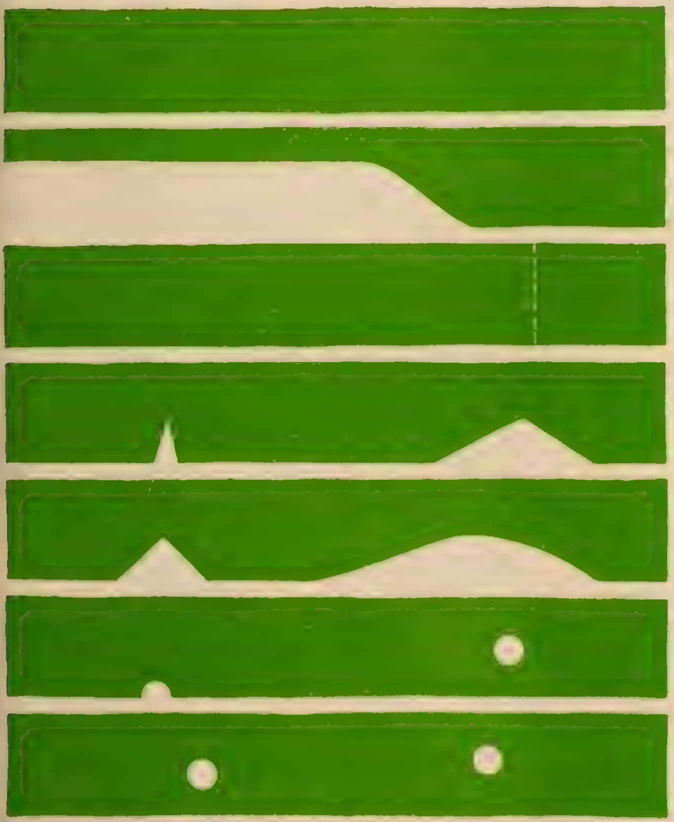
Most of the weight of a suspension bridge hangs from large cables *(see photo)*. Smaller cables are also being used today to suspend roofs of large buildings, such as stadiums, so that no posts will block the view from the seats. In such cases, the weight is pulling on the cables, instead of being supported on posts. To make sure a cable is strong enough, engineers test its *tensile strength*—the amount of weight that can pull on the cable without stretching or breaking it. Here are some ways you can test the tensile strength of paper.

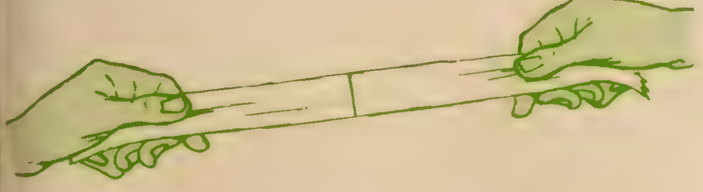
Each of the four cables supporting the Verrazano-Narrows Bridge in New York has a tensile strength of more than 30,000 tons. Each tower supports about 132,000 tons.

H OF PAPER

by David Webster

Cut up a piece of paper into a lot of strips that are about ¾ of an inch wide and 8½ inches long. Then cut them in the shapes shown below. Make up some shapes of your own, too. Where do you think each strip will break when you pull it with your hands? Before pulling, use a pencil to mark the place where you think the strip will rip. If you can't break some strips, have someone else pull on one end.

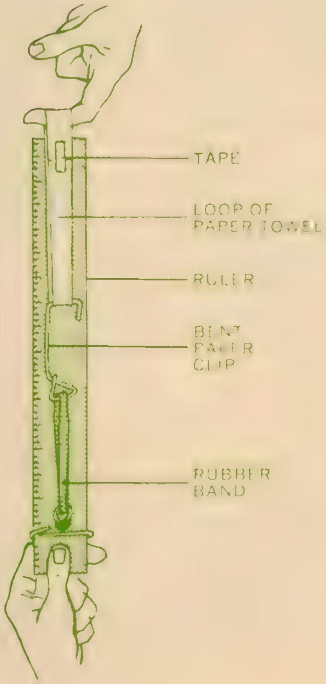




Testing the Strength of Paper Towels

You have probably seen television commercials claiming that a certain brand of paper towels is stronger than other kinds of paper towels. Pretend you have been hired to test the strength of various kinds of paper towels. How would you do it?

One way to make a paper testing machine is shown below. You could build something like this or invent one yourself. Are all kinds of paper towels about the same strength? How strong are the towels when they are wet? ■



Pull ruler downward and see how far the rubber band stretches before the strip of paper towel breaks.

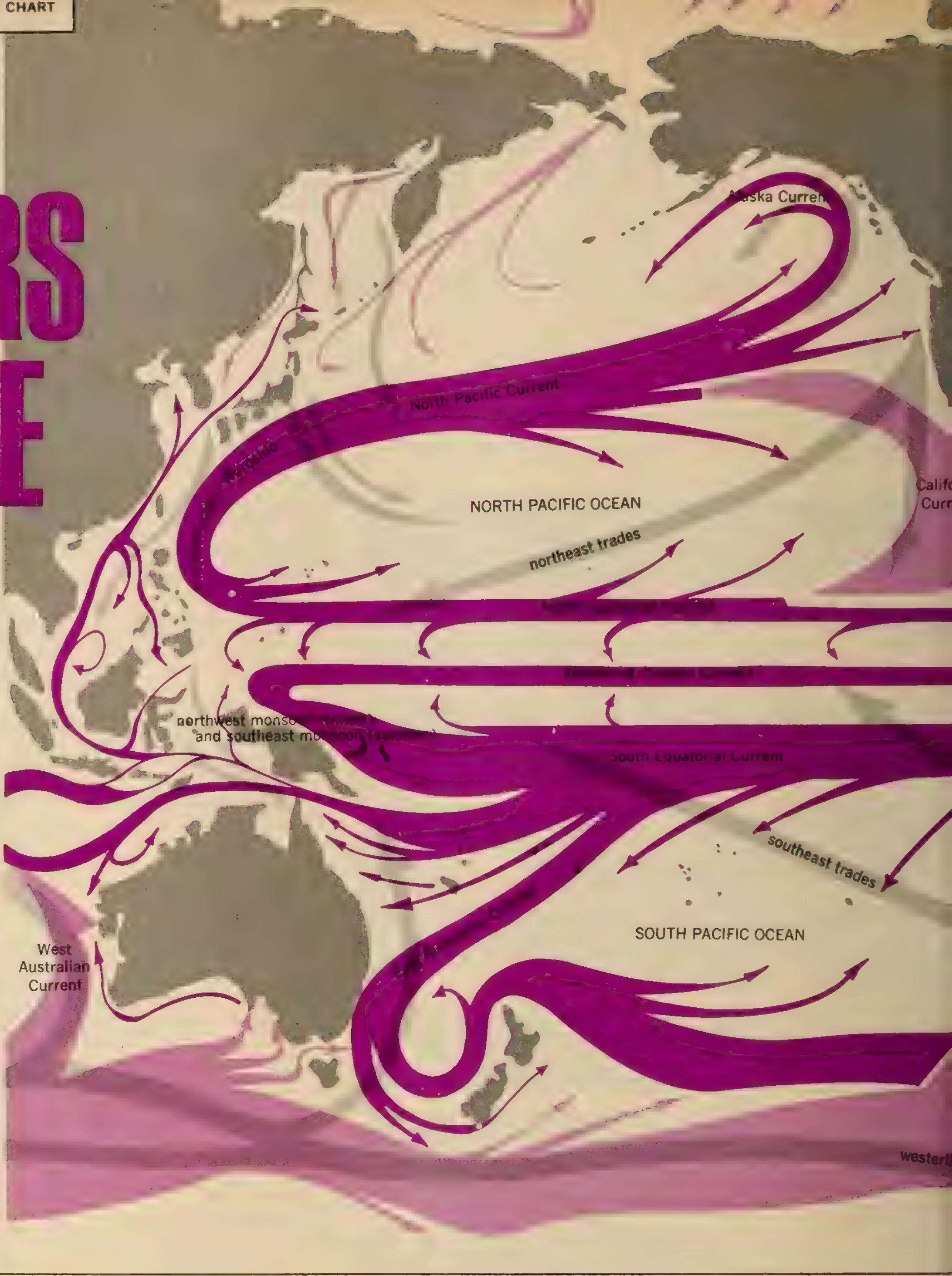
MATERIAL	STRENGTH IN POUNDS PER SQUARE INCH
STEEL	125,000
CAST IRON	60,000
ALUMINUM	58,000
WHITE OAK WOOD	800
WHITE PINE WOOD	300

This chart shows the tensile strength of some materials. Which is the strongest? Can you guess why airplanes are made with aluminum if it is only half as strong as steel? Why are houses built of pine wood even though it is much weaker than oak?

nature and science | WALL CHART

February 27, 1967

RIVERS IN THE SEA

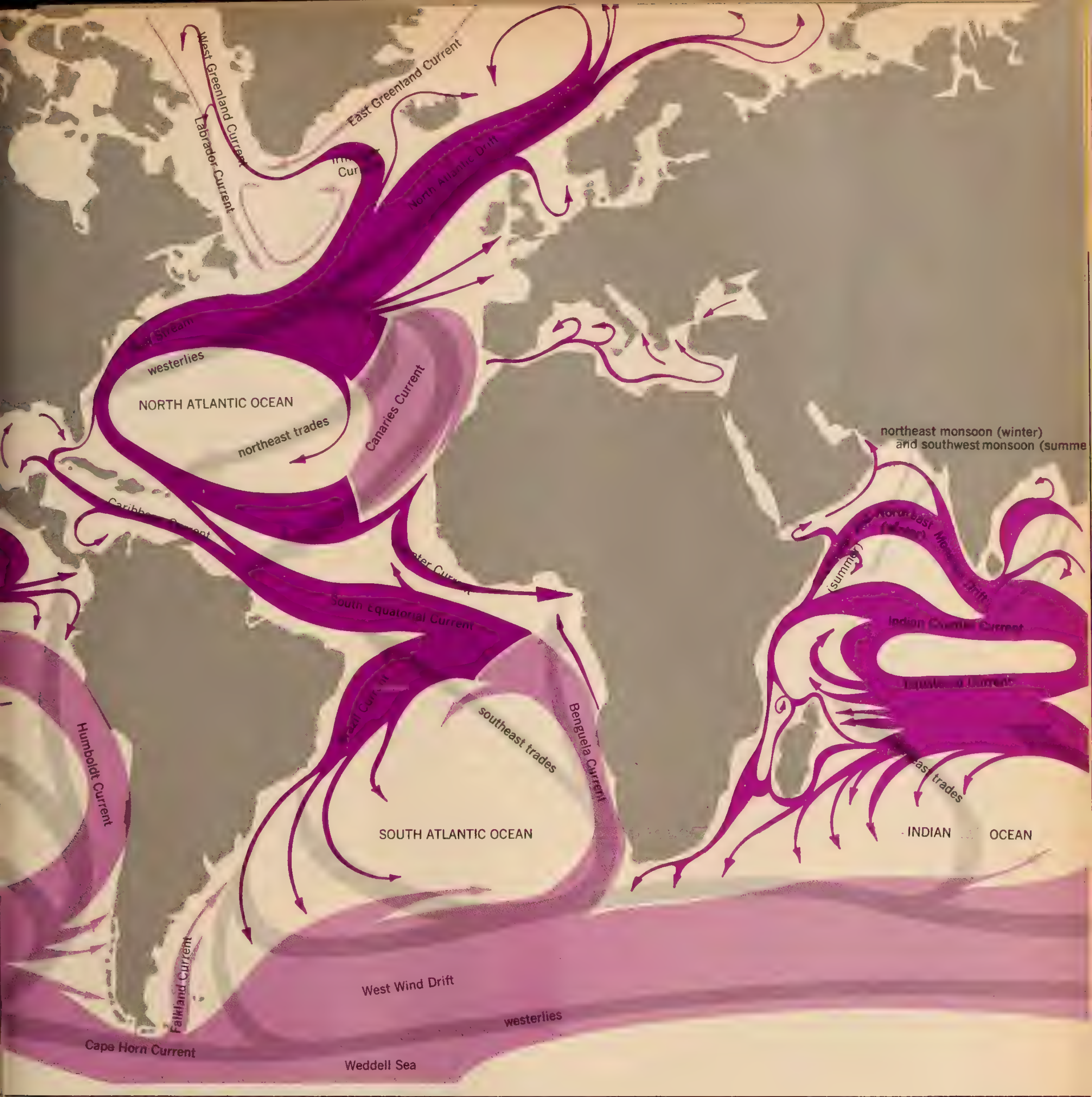

ska Curren
North Pacific Current
NORTH PACIFIC OCEAN
Califo
Curr
northeast trades
northwest monso
and southeast mo
outh Equatorial Current
southeast trades
SOUTH PACIFIC OCEAN
West
Australian
Current
westerl

Surface Currents: The waters of the world—from the smallest puddle to the deepest ocean—are always in motion. This world map shows how the major surface currents are driven by prevailing winds, sometimes as fast as six miles an hour. The warm currents are in dark red, the cold currents in light red, and the prevailing winds in gray. A prevailing wind is one that blows more or less steadily along a certain path for most of the year.

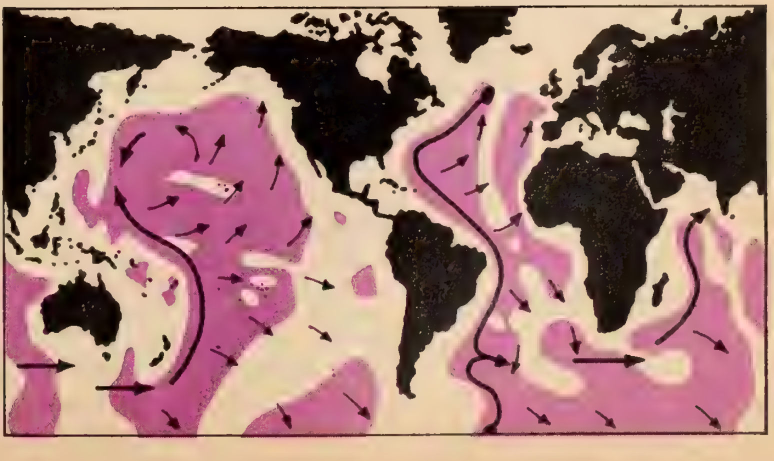
You can see that almost all of the surface currents flow in paths that are loops. Ocean water driven by the wind from one part of the sea is replaced by water flowing from another part. The result is a current that flows around and around in a large loop.

Deep beneath the surface, currents moving as slow as one to three miles a day flow great distances alo the bottoms of the oceans. When deep currents me the current with the colder water wedges itself und the current with warmer water. Cold water is heav than warm water. This results in cool downward a warm upward ocean currents.

Just southeast of Greenland on the map you can s the current labeled "North Atlantic Drift." It is blo from the Gulf Stream northeast into the Arctic Oce This current does not seem to join any other curre and thus form a loop. However, water from the No Atlantic Drift is cooled in the Arctic Ocean, sinks, a flows southward along the ocean bottom toward t Equator, forming part of the Atlantic Deep Curre (see smaller map).

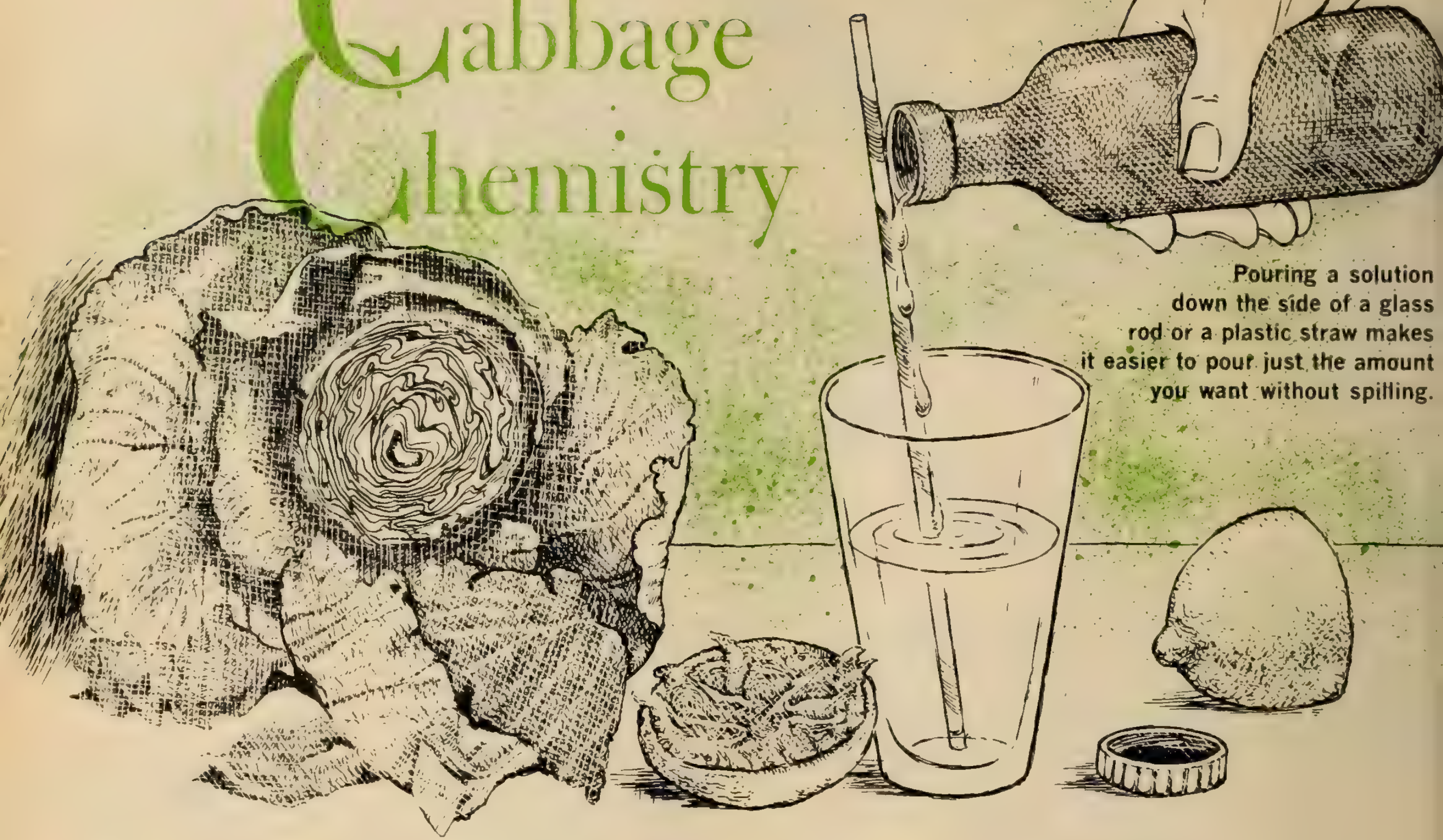

West Greenland Current
East Greenland Current
Labrador Current
North Atlantic Drift
Stream
westerlies
NORTH ATLANTIC OCEAN
northeast trades
Canaries Current
Caribbean Current
ter Current
South Equatorial Current
Brazil Current
southeast trades
Benguela Current
Humboldt Current
SOUTH ATLANTIC OCEAN
northeast monsoon (winter)
and southwest monsoon (summe
Northeast Monsoon Drift
(summer)
Indian Counter Current
Equatorial Current
trades
INDIAN OCEAN
Falkland Current
West Wind Drift
westerlies
Cape Horn Current
Weddell Sea

Currents: The other major source of cold water Weddell Sea in the Antarctic. This current, colder the deep water flowing southward from the Arctic, flows toward the Equator. When the two meet, eavier Antarctic deep water wedges itself under armer water flowing down from the Arctic. Near quator, some of the deep-current water rises and ces water blown westward along the Equator in tlantic, Pacific, and Indian Oceans. Deep cold- currents, then, follow a world-wide pattern dif- t from surface currents.



art was adapted from World Beneath the Oceans, *by T. F. Gaskell, The History Press, Garden City, N.Y., 1964. Copyright © 1964 by Aldus Books London.*

Cabbage Chemistry



Pouring a solution down the side of a glass rod or a plastic straw makes it easier to pour just the amount you want without spilling.

■ Have you ever noticed that squeezing a lemon into a cup of tea changes the color of the tea? You can see this better when the tea is in a white cup. It happens because tea is an *indicator*—a substance that changes color when certain other kinds of substances are put into it.

Lemons, for example, contain *acid*. And acid substances change the color of an indicator in one way. Ammonia, on the other hand, is a *basic* material, or a *base* for short. And basic materials change the color of an indicator in another way. By finding out how the color of a particular indicator is changed by an acid or a base, you can use the indicator to find out whether other substances are acids or bases. And you can also find other substances that can be used as indicators.

Red Cabbage-ade

A good indicator to work with is red cabbage juice. You can't buy this in the store, but you can buy a head of red cabbage and boil some pieces of it in a little water to make the juice. When the juice is cool, pour a little into a small bottle and seal it with a cork or cap. This will be your *standard indicator solution*. When you want to see how another batch of indicator has changed in color, you can compare it to the standard solution.

Pour a small amount of indicator into a glass, then stir in some lemon juice (the kind you buy in a bottle or a plastic "lemon" will do as well as fresh lemon juice). Compare the color of the indicator with acid in it to that of your standard indicator solution. Then add some more lemon juice and see if the color of the indicator changes any more.

PROJECTS

- When an acid and a base are combined, they form a new substance. Mix some lemon juice with baking soda. The foam you see is caused by a gas called *carbon dioxide*, which is made by the combination of the acid and the base. This is the same gas that is dissolved in soda pop to make it bubble and fizz when the bottle is opened. Do you think that the soda pop contains acid? Test it with an indicator. What can you add to the soda pop to "un-fizz" it? If you succeed, test the un-fizzed pop with an indicator.
- Stir a bar of soap in a dish of warm water until bubbles form. Pour in some indicator. Is the soap solution acid or base? What can you add to change the color of the solution? Once it is changed, can you make bubbles form again by stirring the soap in the solution or heating it? Do you think that soap must be acid or base in order to make bubbles?

To find out how a base changes the color of your indicator, carefully pour a little ammonia from a bottle into a cup of water. *(Don't get any of the ammonia on your skin or eyes, because it can burn.)* Now pour some fresh indicator solution into a glass and stir in some of the ammonia solution. Compare this *working solution* of indicator-and-base to the color of your standard solution. Will adding more of the base change the indicator's color further?

Can you guess what will happen if you mix an acid and a base both into some indicator? To find out, stir lemon juice—a little bit at a time—into your working solution of indicator and ammonia water. See if you can change the working solution back to the color of the standard indicator solution. Do you think that when an acid and a base are mixed together they somehow "cancel" each other's effect on the color of the indicator?

See how many substances around your home you can identify as acids or bases by testing them with your indicator. How about spinach juice, berry juice, or ink? How many other substances can you identify as indicators by testing them with lemon juice and ammonia water? ■

This article is based on The Chemistry of a Lemon, *by A. Harris Stone, Prentice-Hall, Inc., Englewood Cliffs, New Jersey. Copyright © 1966 by A. Harris Stone. Adapted by permission.*

Brain-Booster Contest Winners

Here are the winners of the Brain-Booster Contest that was announced in the October 31, 1966 issue of Nature and Science. The winners were selected on the basis of their answers to all six questions. The winner in each group was awarded his choice of a 10-power or a 100-power student microscope or a 10-power telescope, provided through the courtesy of Bausch & Lomb Incorporated. Each of the runner-ups received a copy of Brain-Boosters, a new book by Mr. Brain-Booster himself.

FOURTH GRADE AND BELOW WINNER:

Rena Gorlin, Rego Park, New York.
Runner-ups: Scott Gilman, Greenfield, Mass.; John Stephenson, Whitewater, Wisconsin; Dennis Buffenmyer, Ephrata, Pennsylvania.

FIFTH GRADE WINNER:

Jim Leader, Wayne, Pennsylvania.
Runner-ups: Kenny Koster, Cincinnati, Ohio; Jerry Blackwell, Houston, Texas; Carl Taswell, Rochester, Minnesota.

SIXTH GRADE WINNER:

Julie Drown, San Juan Capistrano, California.
Runner-ups: David Christensen, Rochester, New York; Robert Sheridan, Wollaston, Massachusetts; Stephen Painter III, South Orange, New Jersey.

SEVENTH GRADE AND ABOVE WINNER:

Donald Lurye, Huntington, New York.
Runner-ups: Richard Livingston, Bayside, New York; Joan Watters, Houston, Texas; Jeff Jackson, Geneseo, New York.

ADULT WINNER:

Harry Baum, New Hartford, New York.
Runner-ups: George Bateman, Orlando, Florida; Clifton Dukes, Jr., Atlanta, Georgia; William Phillips, Somerville, Massachusetts.

Answers to the Contest Questions

Question 1: Water rises higher in thin capillary tubes than in thick ones. Why does it rise higher in thick blotters than in thin ones?
Answer: The blotter is a random network of capillaries. There are just as many capillaries running from side to side as up and down. Each capillary that reaches the edge of the paper is like an opened spigot that drains off the water it carries. In a wide blotter there will be more capillaries going up and down than capillaries that reach the sides, so this draining off becomes less important. In a blotter of unlimited width the water would rise to its maximum height. *Mr. Harry Baum, New Hartford, New York*

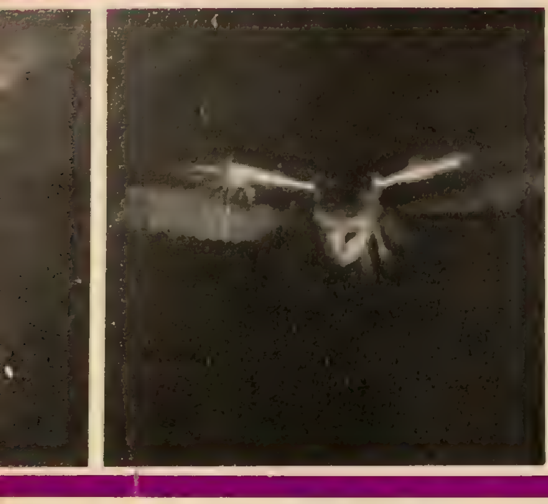
Question 2: Why doesn't a ball point pen write when the point is higher than the rest of the pen?
Answer: When the point is lower than the rest of the pen, gravity pulls the ink down to the point. When the point is held up, the ink flows away from the point, so the pen doesn't write. *Rena Gorlin, Rego Park, New York*

Question 3: Why is the prime U.S. rocket launching site located in Florida rather than in Arizona or California?
Answer: All space flights are launched eastward, which is the direction of the earth's rotation. This gives the rocket extra speed. The closer you get to the equator, the more speed you get from launching eastward. So Florida is the best spot. *Donald Lurye, Huntington, New York*

Question 4: Why do sharp nails split wood more often than blunt nails?
Answer: Sharp nails split wood like a wedge. A blunt nail punches a hole to penetrate the wood. *Stephen Painter III, South Orange, New Jersey*

Question 5: Which of four containers would collect the most water in a rainstorm? In which would the water be deepest?
Answer: Container A would collect the most rain because it has the biggest mouth of all. B would collect the second most rain and would be deepest because it is narrowest at the bottom. *Jim Leader, Wayne, Pennsylvania*

Question 6: A blackout happens at 5:30 in the afternoon. The next morning an electric clock says 3:30 when it is 11:00 by your wristwatch. How long was the electricity off, and when did it go back on?
Answer: The electricity was off for 7½ hours and it went back on at 1 A.M.



Catching Mice In The Dark

by Roger Payne

In the first two parts of this article, the author told how he proved that a barn owl can catch mice in the dark by detecting their sounds. He also learned something about the amazing accuracy of an owl's hearing. In this last part, Dr. Roger Payne tells how he discovered the ways in which an owl actually catches a mouse in its talons.

■ Locating a mouse in the dark by the sounds it makes is only one part of an owl's problem. It must also *catch* the mouse. How does an owl actually catch mice it cannot see? To find out I had to watch an owl fly and strike in total darkness. My problem was to find a way of "seeing" in the dark so that I could watch what was happening.

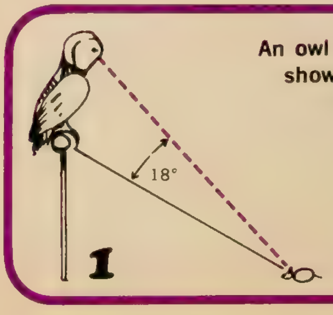
To do this, I placed in the "owl room" several lamps that were completely covered with filters. No light could pass through the filters, but the heat from the bulbs could escape. By looking through a "sniperscope" (a device that changes invisible heat energy into light), I could watch the owl hunting a live mouse in darkness.

Because things happen so fast during an owl's strike, and because I wanted to be sure I saw exactly what happened, I made several motion pictures of the owl striking a mouse in the dark. I used heat-sensitive film and aimed the camera with the help of the sniperscope. Once heat-sensitive film is developed, it can be run on a regular movie projector. By running my film slowly, I could study the owl's flight in detail. I also made moving pictures of the same owl hunting in the light. I found that its behavior during the strike was quite different in light and in darkness.

How the Strikes Differed

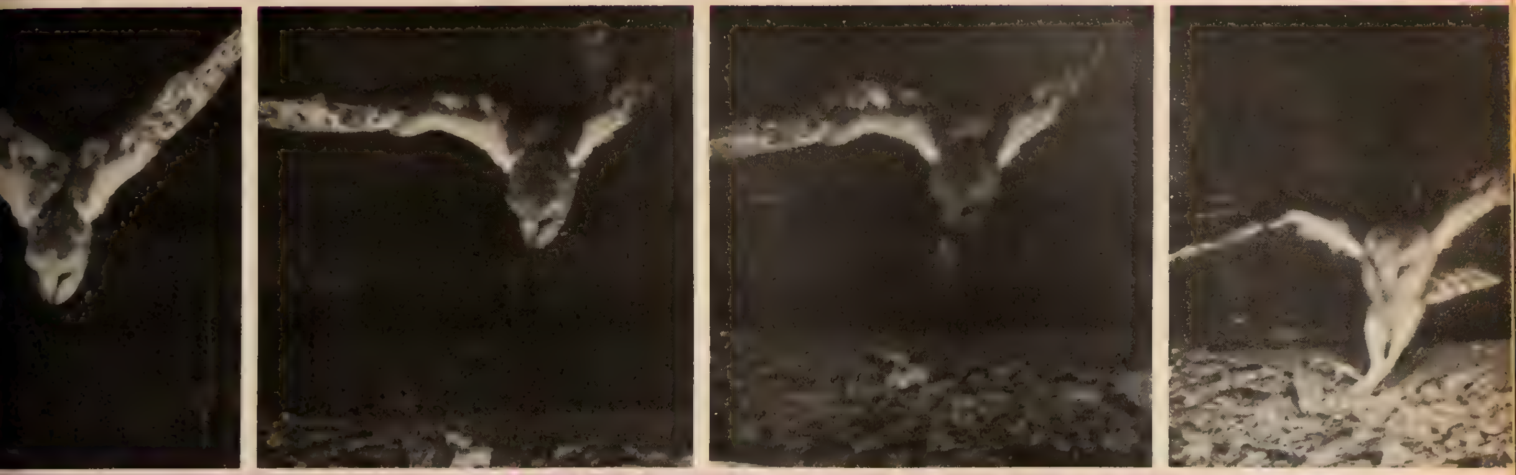
The first motion pictures I made show how a barn owl strikes a mouse when it *can* see. When I tossed a mouse into the leaves, the owl turned quickly to face it, leaned forward slightly, and held perfectly still. Then it pushed off from the perch, made one stroke with its wings and glided straight to the mouse. During most of the flight the owl's feet were tucked beneath its tail. But, about three feet from the mouse, it suddenly swung its feet forward until they almost touched its bill. Then the owl pulled its head back, as if it had started out to dive into the leaves but decided at the last moment to land feet first. With its head held high, eyes closed, legs stretched out, and claws spread, the owl struck.

The next motion pictures I made show strikes by an owl hunting in total darkness. Some photos from the



An owl locates mice with its ears (alon shown in red) but catches them with i (black line). These drawings sho the angle between the lines vary with dis

This article was adapted from How Owls Hunt, *by Roger Payne.* *Copyright © 1966 by Educational Services Incorporated, Newton, Massachusetts.* *This booklet was written for the Elementary Science Study project of ESI, and will be published by the Webster Division of McGraw-Hill Book Company. ESS is supported by the National Science Foundation. Dr. Payne is an Assistant Professor at the Institute for Research in Animal Behavior, run jointly by The Rockefeller University and the New York Zoological Society.*



The photos above *(left to right)* show a barn owl as it struck at a mouse in the dark. The owl's feet swung forward, close to its head. Then at the last moment, the owl pulled its head back, spread its claws, closed its eyes, and struck at a mouse on the leaf-covered floor.

movies are shown on this page. As it had done in light, it turned first to face the sound and leaned forward. When the mouse became still, the owl took off and flapped its wings several times, its feet swinging beneath it. It moved only about half as fast as it had moved when there was light. Again, in the last moment of flight the owl swung its feet forward, drew its head back, spread its claws and struck.

Why does the owl use this particular style of attack? I think it is a very neat way to avoid a problem concerned with angles. Remember, although an owl locates a mouse with its ears, it must strike the mouse with its feet. This creates a problem for the owl, as shown in Diagram 1. The diagram shows two side views of an owl sitting on a perch in the owl room.

The only difference between the two views is that in the first the mouse is closer to the owl than it is in the second. The red line is drawn between the owl's *ears* and the mouse. The black line goes from the owl's *feet* to the mouse. The red line is the path the owl should fly as indicated by its ears. But the black line is the path it must fly if it is to hit the mouse with its feet.

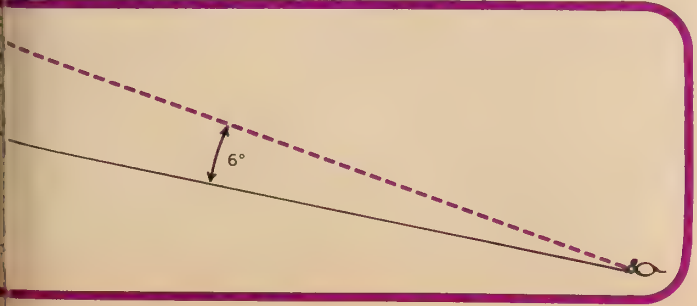
Notice that when the distance between the mouse and the owl changes, the angle between the two lines will be different. This means that the owl cannot simply make the same correction in the flight path and still hit the mouse at all times. Instead, it must make a new correction for each different distance. The owl would have to know not only the direction to fly to a sound source, but also the distance.

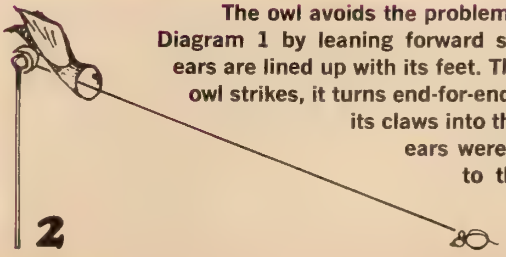
As it turns out, a barn owl avoids this tricky little problem in angles in a very simple way. Diagram 2 shows how. As the owl listens to the mouse, it leans forward so its feet can shove it off along a direct path from its ears to the mouse on the floor. Then, at the last moment, it turns end-for-end in midair, pulling its head back and thrusting its feet forward. This brings the owl's claws into the exact path that its ears were following a moment before!

Which Way Is the Mouse Going?

Everything I have mentioned improves an owl's accuracy in locating a mouse. However, even if the owl knows exactly where the mouse is, it will lose it unless it can get several claws into it. How does it do this? To find

(Continued on the next page)





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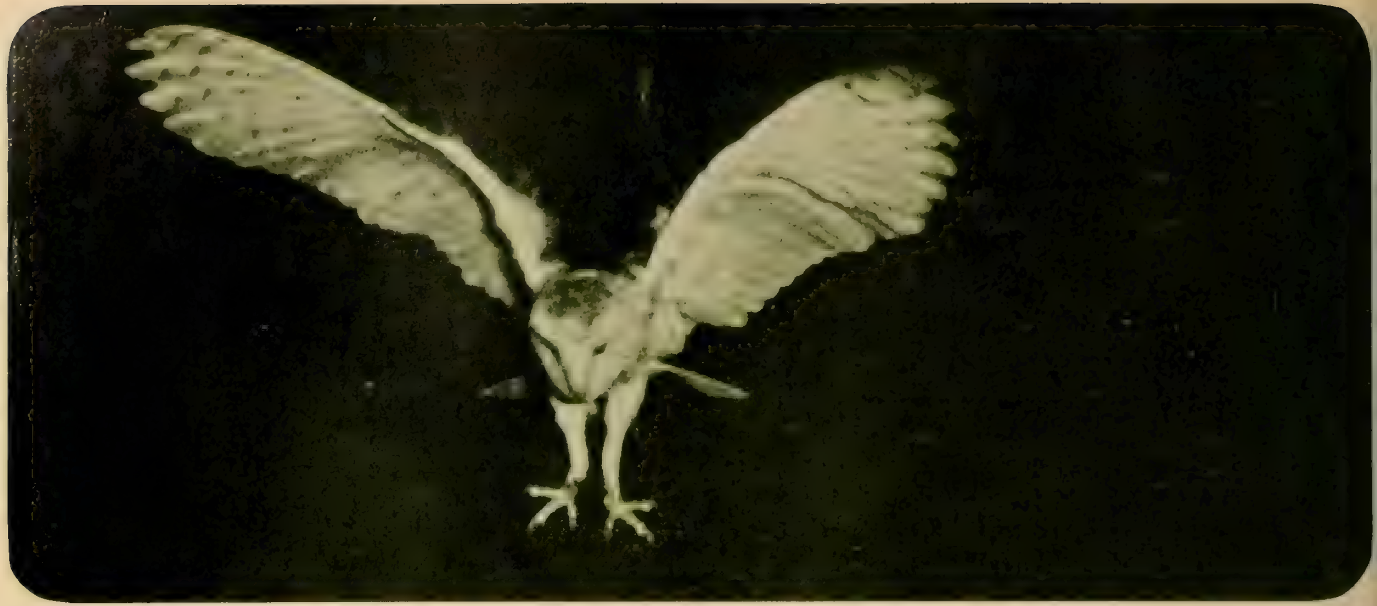
The owl avoids the problem shown in Diagram 1 by leaning forward so that its ears are lined up with its feet. Then as the owl strikes, it turns end-for-end, bringing its claws into the path its ears were following to the target.



Catching Mice in the Dark (continued)

out, I took photographs of a barn owl with its claws stretched out the instant before a strike in total darkness (*see photo*). Also, by putting a piece of paper over a hidden loudspeaker that was playing mouse sounds, I got the owl to stab holes in the paper with its claws (*see diagram on next page*). The pattern shows that four claws of each foot are spaced evenly and that these spaces are the same as those between neighboring claws on different feet. Both feet are lined up perfectly. By holding its claws spread in this way, the owl covers the largest possible strike area.

The strike area surrounded by an owl's claws is about the same size as a mouse. Since the length and width are about the same, an owl will get most claws into a mouse if he can get the strike pattern lined up with the mouse and directly over it. But this would mean that an owl has to discover *by listening,* not only where a mouse *is,* but also *the direction in which it faces*. Perhaps one of the biggest surprises I have gotten during my research was to find out that an owl can do this!

Here is how I found it out. I had noticed, by carefully studying the movies I took in darkness, that though the owl flew at a mouse directly, turning end-for-end just before striking, in some cases it also spun about for a quarter turn or so just before its claws hit the mouse. At first I thought this was just due to the owl's losing its balance or some such thing. Eventually, I began to feel that it might be something the owl really intended to do. Could the owl actually tell in which direction a mouse was headed just by listening to it? It didn't seem possible. However, I tried to figure out what sort of technique the owl could use, just in case it was, in fact, doing this.

How would you tell which way a mouse was facing just by listening? Since mice do not walk sideways, I can assume that if I hear a mouse move from one place to another and stop, it must be facing in the direction it was going. By doing the following experiments, I found that this is just the way an owl figures out which way a mouse faces.

I took a dead mouse, glued a small leaf to its body, and tied a string to its tail. By pulling the string I could move the mouse in a totally dark room. With a sniperscope, I could watch the owl strike it. I did this experiment 18 times, moving the mouse in many different directions.

In six of the trials I moved the mouse directly across the path the owl had to fly in order to reach it, so that the owl didn't have to turn, or spin, in flight to be in the best strike position. In all six trials the owl did not spin. In each of the 12 remaining trials, however, when I pulled the mouse over different paths, the owl spun during the last moment of flight until its feet were in the best strike position.

It was clear that the owl had discovered the direction of the mouse's motion by hearing and not by some other means. I knew this because in several experiments I made a dead mouse "walk" sideways by dragging it by the fur on its side instead of by its tail. The owl still aligned its claws along the line of motion of the mouse. In these tests, the owl ended up in the *least* favorable striking position. This meant that the owl was "assuming" that the mouse faced in the direction it was going.

How Does an Owl Judge Distance?

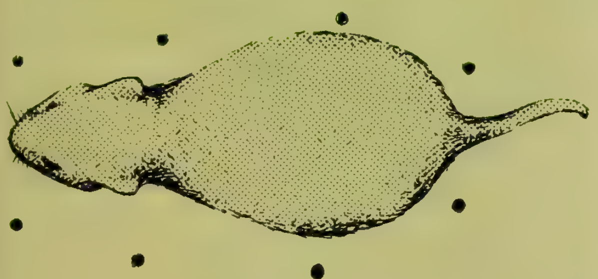
Although the owl's ears can locate the direction the mouse is facing, as well as the up-and-down and side-to-side direction it must fly in order to strike a mouse, this doesn't tell us whether an owl can detect the *distance* to a mouse. I am as yet not sure whether the owl can tell distance by hearing. The evidence seems to point both ways.

Remember that owls turn end-for-end in midair just before striking the ground. This suggests that they must know how far to go before they stop flying and turn end-for-end; that is, that they know how far away a sound is.

However, what about the difference between an owl's strike in light and its strike in darkness? In darkness the owl leaves its feet swinging down, as if it were prepared to land, because it does not know the instant when a landing may be necessary. Also, its flapping flight in darkness looks as if it might be a way for the owl to tell how close it is to the ground. It might be feeling changes in pressure on the undersides of its wings caused by backdrafts from the ground as it gets close. It might use these pressure changes as the signal to bring its feet forward into striking position.

I did an experiment that I hoped would test whether an owl can judge distance to a sound source with its ears. As before, I let the owl strike at a dead mouse with a leaf attached to it. But this time I put this mouse on a fine net several feet above the floor. By pulling a string tied to the mouse I rustled the leaf. When the owl heard the rustling noise, it struck. In almost every trial, however, the owl passed over the net and struck on the floor, at a spot directly beyond the leaf. These results seem to mean that the owl was not able to judge distance by hearing. It had to rely on sensations in its wings, or some such method, to tell whether it was getting close to the ground.

However, owls have memories. My owls may have memorized how far away the floor was in any of several directions. If we give them credit for this memory, the results can be explained this way: The owl was so used to flying from its perch to the floor that it did not believe its ears when they indicated that a leaf was being rustled in midair. (After all, mice do not hover in midair.)



Each of these eight dots represents the talon mark of an owl when it struck. Notice how the talons would enclose a meadow mouse, the most common food of barn owls.

Because of this possibility, my experiment really tells me nothing. So, I have planned the following experiment. I will mount the owl's perch on a *hydraulic* lift. This will allow me to raise and lower the owl—once the lights are out—so smoothly and slowly that it will never know how high off the ground it is before a strike. Then, if the owl cannot strike mice on the floor from a new height, I will conclude that the owl gets its information about distance from remembering its surroundings. If the owl *can* strike mice on the floor but fails to find them on the net, then it must have some way of detecting its approach to the floor as it flies. But if the owl is able to strike mice suspended on a net, this will mean that the owl can tell distance by hearing.

How Do Owls Hunt in the Wild?

The remarkable hearing of owls was not developed simply to amuse biologists studying them in large, dark rooms. Unfortunately, I do not know how much barn owls use their ears to locate prey in the wild. I have heard that great gray owls can dive into deep snow and bring up mice, and this is exciting to me as an example of natural hunting by hearing alone. In this case I imagine that the noise which gives away the presence of mice underneath the snow is chewing, a noise which contains many of the same tones that leaf rustles contain.

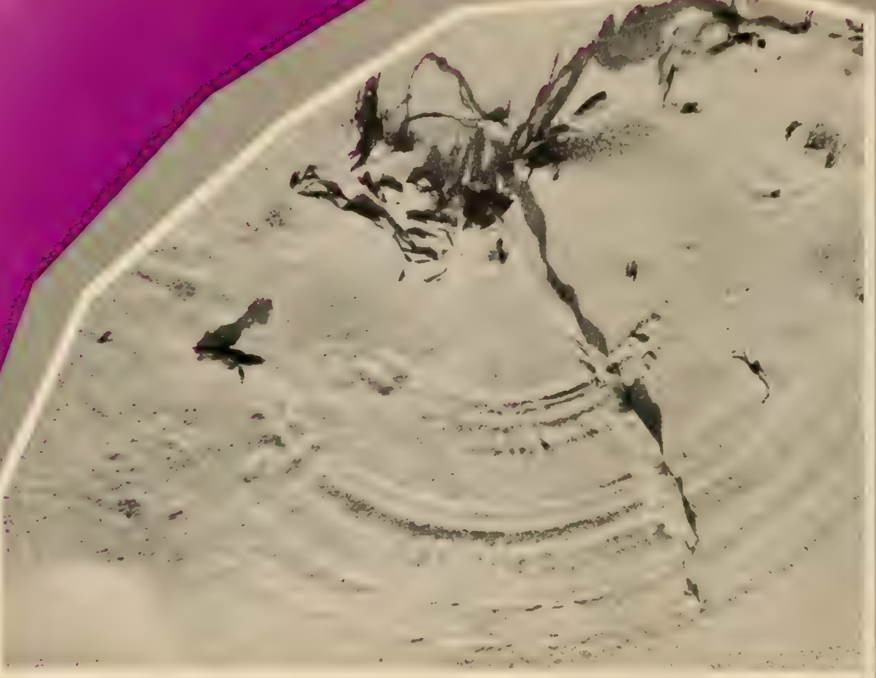
In the case of barn owls, they surely can—and often must—hunt chiefly using their eyes. But the experiments which I have described show that they need not go hungry even on the darkest night or when hunting the best-hidden mice. When wild owls fly through the woods, their excellent eyes must be busy spotting obstacles like twigs and branches which they must avoid in flight. If you are lucky enough to see an owl in the wild flying through the woods at night, you will notice that it flies down from a branch, swooping low and then rising steeply to a perch. Is it keeping low so that it can see branches as silhouettes against the brighter sky?

In any case, the barn owl's systems of vision and hearing are wonderfully suited for finding prey that scuttles in and out of shadows and secret runways. This is probably one of the chief reasons that these beautiful birds have been able to survive and spread over the entire world ■

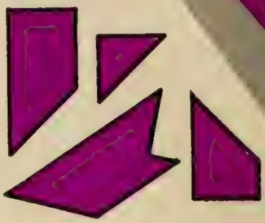
(Correction: The author, Dr. Roger Payne, began his study of owls at Cornell University, not at Dartmouth College as reported in Part 1 of "How Owls Hunt.")

BRAIN BOOSTERS

by DAVID WEBSTER



MYSTERY PHOTO What made the circular marks in the sand?



FUN WITH NUMBERS AND SHAPES

Arrange these four shapes to make a "T"

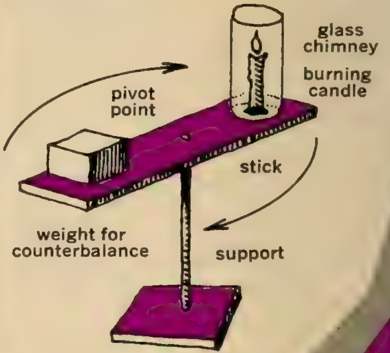
Submitted by Mike Eppling,
Lincoln, Massachusetts

CAN YOU DO IT?

Can you find two liquids that will not mix together, even when they are shaken?

WHAT WOULD HAPPEN IF?

Which way will the flame point when the candle is spun around in a circle?



FOR SCIENCE EXPERTS ONLY

Can you figure out the weight of one page in a telephone book?

(Hint: use the bathroom scales.)

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The sponge curled because the top side dried out before the bottom. As a sponge dries it gets a little smaller, which makes the sponge bend when only one side is still wet.

Can you do it? To see 10 reflections, hold a hand mirror beside your eye. Then stand with your nose touching the bathroom mirror and adjust the small mirror until you see a lot of eyes. Could you make even more reflections with three mirrors?

What will happen if? As you move your hand and the pencil together, they will meet at the center of the yardstick. What will happen if one end of the yardstick is weighted with something like a piece of clay?

Fun with numbers and shapes? The Mystery Photo in the last issue is composed of more than 105,340 dots.

For science experts only: You can boil water in a paper cup because paper will not burn unless it gets a lot hotter than boiling water. The paper is kept cool by the boiling water, and never gets hot enough to catch fire.

Using This Issue . . .
(continued from page 2T)

stopped swirling, gently reach in and slit the bag near the bottom with a sharp knife. You can see the heavier (cold) water flow out and sink beneath the lighter (warm) water.

Cabbage Chemistry

This SCIENCE WORKSHOP will give your pupils some practice in a simple but useful technique of chemical analysis—the detection of acids and bases by means of an indicator.

A handy indicator used by chemists is litmus paper—small strips of pink and blue paper dipped in litmus solution—which can be obtained from a drug store. The pink paper turns blue when dipped in a base, and the blue paper turns pink when dipped in an acid.

Your pupils can make their own version of the litmus paper indicator by soaking paper towels or filter paper in a deep purple solution of red cabbage juice, made by boiling small pieces of the vegetable in a little water or soaking them in alcohol. Let the paper dry, then cut it up into small strips, which can be dipped into various solutions to find out if they are acid or base.

A base is also known as an *alkali,* or an alkaline substance. In many areas, the drinking water contains chemicals that make it slightly alkaline. Does yours?

Have your pupils think of a number of household substances—including foods—and list their guesses as to whether each substance is acid or alkaline. Then have them test these substances with litmus (or cabbage juice) paper and compare their findings. (Be sure to have them test foods, such as candy, that have a high sugar content.)

They will probably find many substances that do not change the color of the indicator. Such substances are likely to be *salts*—a third important class of chemicals. (A solution of common table salt, for example, will not affect the color of the indicator.) A salt is produced when an acid and a base *react* with each other, or combine to form new chemicals. The same reaction may also produce water or another substance (such as carbon dioxide when lemon juice combines with baking soda). The combination of an acid with a base is called a "neutralizing" reaction because it produces substances that are neither acid nor base.

To many people, the word "acid" suggests a dangerous liquid that will burn the skin and "eat," or dissolve, metals. There are many such "strong" acids, but your pupils may be surprised to find how many of the foods and other substances they use regularly contain weak acids.

To show them that even "weak" acids can have a destructive effect over long periods of time, soak some clean chicken bones in a concentrated solution of vinegar for several days. Also, while the enamel of a tooth is resistant to vinegar, you might have someone who has lost a tooth soak it in a glass of cola drink (*not* the diet kind) a few days. It may dissolve quickly because of the drink's acid.

Catching Mice in the Dark

The author's main reason for writing this series of articles is to give some idea of how a scientist tries to solve a problem that interests him. It helps destroy the myth that a scientist's work can only be understood by other scientists. It tells how one person, in an uncomplicated fashion, puzzled over a problem that he enjoyed working on. Hopefully, the articles will give children a more realistic picture of how science "works."

In addition, this series of articles illustrates how owls have become adapted to their predatory role. You might have your pupils list the different adaptations that have been revealed in "How Owls Hunt." What behavioral ways and body structures enable owls to catch their prey? Some examples of structural adaptations are an owl's talons, keen hearing, and soft-edged wing feathers. One behavioral adaptation is described in the article in this issue: the way the owl leans forward to align its talons and ears just before flying, then turns end-for-end when it strikes.

References

- Watch for the publication of Dr. Payne's booklet, *How Owls Hunt,* by the Webster Division of McGraw-Hill Book Company.
- *The World of the Great Horned Owl,* by G. Ronald Austing and John B. Holt, Jr. (Lippincott Co., Philadelphia, 1966, $4.95) describes the life of this widespread, large owl and is illustrated with about 100 black and white photos.

Recent Natural History Books . . .
(continued from page 1T)

indrical, straight-sided, coiled, or any one of a dozen other shapes illustrated in this book. The author is also a fine photographer. His close-ups of these insects and their cases (most of them less than one inch long) are marvels of clarity. Altogether an unusual book for nearly any age. Recommended for fifth grade and up.

Fall Is Here, by Dorothy Sterling (Natural History Press, 96 pp., $3.25). So many complex ideas need to be simplified to explain what happens in the fall that a book on the subject can never be wholly satisfactory. There must be explanations of how leaves turn color and descriptions of winter buds and seeds. The stories of migrating butterflies and elk and birds must be told. The journeys of salmon, the cocoon-spinning of caterpillars, and the hibernation of other animals must all fit in a book about the fall out-of-doors. All this information is here but the subject does not lend itself well to organization. However there is an index, and fourth and fifth graders should find it useful. They should especially like the section at the end which has suggestions for activities in the fall. The book is attractively illustrated.

All About Cats, by Carl Burger (Random House, 144 pp., $1.95) is a well-written survey of the whole cat family. About a third of the book is devoted to information about its wild representatives, from the lion to the Kaffir cat. Domestic cats are thoroughly discussed and the many different breeds are described. There is a chapter on man's attitude toward the cat, and another on the mind of the cat. The book contains an index and a bibliography. There is an appendix showing the cat's family tree. For ages 10 and up.

The Swift Deer, by Robert M. McClung (Random House, 82 pp., $1.95). This is a survey of the deer family. Although it could be a reference book for many different grade levels, it is probably best suited for 9- to 11-year-olds. Deer from all over the world are included, but the bulk of the book is devoted to North American species. There are chapters on elk, caribou,

(Continued on page 4T)

Recent Natural History Books . . .
(continued from page 3T)

moose, mule deer, and black-tailed deer. The life of the white-tailed deer is told in detail. The author's experience enables him to pick out the things children especially want to know: why some deer have bigger antlers than others; why it is so rare to find old antlers in the woods; how much the average deer weighs, and how long it lives. All these questions and many more are answered with authority. Indexed.

The Riddle of Seeds, by Winifred G. Hammond (Coward-McCann, 64 pp., $2.86). Good, clear photographs, a well-planned text, and pages of experiments make this a useful book for the primary school child. In simple language the importance of seeds is shown and how they are formed is explained. The child is made aware of their infinite variety of shape, size, and method of growth. Indexed.

The Living Community, by S. Carl Hirsch (Viking Press, 128 pp., $3.75) is an introduction to ecology for the junior high school student. Although a relatively simple book, it avoids the easy, pat formulas and attempts instead to convey some of the true complexity of the subject. The last three chapters are devoted to the impact of modern man upon the natural world and the problems of conservation. The book is indexed and contains a bibliography. There are attractive black-and-white illustrations.

The African Lion, by Mervyn Cowie (Golden Press, 96 pp., $2.95) and **The African Elephant,** by Rennie Bere (Golden Press, 96 pp., $2.95). These two representatives of the new "World of Animals" series set a high standard. Instead of a rehash of old texts on the subject, each of these books contains fresh material by an author who writes from knowledge gained through extensive personal experience. Rennie Bere was for some years Chief Warden of Uganda National Parks and Mervyn Cowie is Director of the Royal National Parks of Kenya. These books are written for adults but junior high school students should certainly find them useful. Both are illustrated with excellent photographs on nearly every page, many in color.

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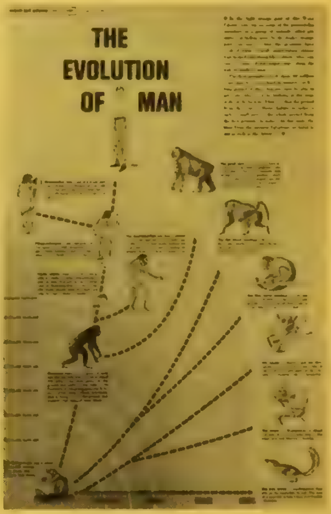

nature and science

TEACHER'S EDITION

VOL. 4 NO. 12 / MARCH 13, 1967 / SECTION 1 OF TWO SECTIONS

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A Style of Understanding

by James H. Werntz, Jr.

■ If one accepts that the attitude toward learning is among the important products of a child's developmental years—about the same in importance as the development of communication skills—then it becomes a responsibility of formal education to present a scheme of attitudes toward which to work.

I believe that any such scheme should include the idea that science is an activity for everyone, and I believe that this should and can be taught in the elementary grades. It seems unfortunate that it has not been more fashionable to look explicitly at the early years of formal learning as a time in which styles of life-long learning are established; the attitudes of youngsters toward major areas of knowledge become remarkably rigid by the time of adolescence. Not to have planted at the very earliest opportunity those attitudes appropriate to a viable style of living is irresponsible at best, dishonest at worst.

All too little is known yet to permit formation of a truly rational design of environmental conditions which encourage development of positive attitudes. Nevertheless, in our efforts to contribute toward the development of a curriculum in mathematics and science for elementary schools, there have been many opportunities for justifying to myself and my colleagues in the MINNEMAST program the value of science and mathematics (beyond mere computational arithmetic) for children.

It is my conviction that there should be a major place in education during the developmental years for ample opportunities to practice the scientific way through concrete experience. It is an equally firm conviction that a relevant assortment of facts and ideas of the physical universe should be part of the intellectual repertory of all children.

But these contributions to intellectual growth speak only to the need for each child to be caught up in one of the major streams of intellectual history of the past few centuries. What of his future and continuing intellectual growth, his style of understanding?

Here an explicit statement of attitudes is needed to serve as implicit guides for the curriculum developer. (Incidentally, by my definition the elementary school curriculum developer embraces the range from subject matter scholar through educational specialist, psychologist, and school administrator to classroom teacher.)

There is no effort here to propose a catechism of beliefs to be learned arbitrarily by all children. I suggest, rather, attitudes in which any thoughtfully planned science (and mathematics) curriculum would find relevance.

In this context the idea of "science as an activity" is not textbook material but the substance of attitudes toward knowledge which can best be imparted by the teacher. I list eight of these attitudes, but neither claim completeness nor venture to set an order of priority. I am, however, most anxious that these ideas should be part of the educational value structure of all children.

Attitudes Toward Knowledge

- The belief that the natural universe, while complex, is understand-

(Continued on page 3T)

Dr. James H. Werntz, Jr., is an Associate Professor of Physics at the University of Minnesota and Director of the Minnesota School Mathematics and Science Center in Minneapolis.

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Mountain Peaks to Seaside Caves**
A scientist takes your pupils on an expedition to collect plants and animals in New Guinea.

● **How Do Your Eyes Help You Keep Your Balance?**
Simple balancing experiments show your pupils how much they depend on vision to locate "up" and "down."

Insects of the Snow
A Wall Chart of insects your pupils may find during the spring thaw.

● **Brain-Boosters**
Suggestions for using this popular feature in the classroom.

Hitch-Hikers of the Sea
How scientists are seeking a way to keep barnacles from sticking to the bottoms of ships.

That's the Way the Ball Bounces
A Science Workshop investigation of "bounciness" and how it changes under different conditions.

How It Works: Automatic Elevator
What makes it go up and down and stop at your floor.

IN THE NEXT ISSUE

A special-topic issue on reproduction: What it is and how it works ...Science Workshops, using guppies and plants...How evolution works through reproduction...Genetics—study of the "blueprints" inside of us.

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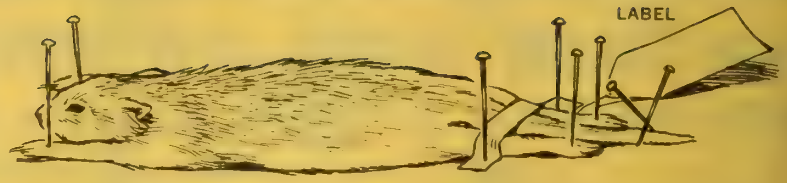

The biologists of the expedition made hundreds of study skins like this one of a mouse. Each specimen is carefully labeled. After preservative is put on the skin, it is stuffed with cotton, sewed up, and then pinned on a drying board.

Expedition to New Guinea

This article gives a good idea of the day-to-day operations of an expedition whose goal was to gather basic information about the plants and animals of an area. Except for some insects and a few other animals, the biologists spent most of their time collecting mammals.

Many people confuse the words "animal" and "mammal." Remind your pupils that *mammals* are a specific group of warm-blooded animals that have hair and mammary glands for giving milk to their young. They include mice, skunks, deer, dogs, and humans, to name a few. *Animals* include mammals, birds, fishes, reptiles, amphibians, insects, and many smaller forms of life.

The article describes the hunting and trapping of mammals, including the use of lights at night. You might remind your pupils that it is illegal to shoot or trap many species of mammals in the United States, although the smaller mammals, such as mice and shrews, are usually not protected by law. When expeditions go to countries such as New Guinea, the scientists first get permission from the government to collect.

The article tells how the mammals were preserved as "study skins" for future study. (The diagram above shows what a study skin looks like.) Collections of specimens like these are kept in museums and universities, where they are valuable references for the study of *taxonomy*—the classification of organisms according to their presumed natural relationships. Taxonomy is the basis for all biological studies, since information about the life of an animal is of little use if the animal is not identified.

The mammals collected on the seventh Archbold Expedition have become part of the collection at The American Museum of Natural History. The collection at the Museum now totals nearly 210,000 specimens.

Keeping Your Balance

You can use this SCIENCE WORKSHOP to develop the concept that gravity pulls on an object as if its weight were all concentrated at one point, and to explore one of the ways that a person's body adjusts to a changing situation even when the person is not thinking about it.

Topics for Class Discussion

- *What makes you fall when you lose your balance?* The earth's gravity, of course. But gravity is *always* pulling your body toward the center of the earth *(see "Have You Ever Been Weightless?"*, N&S, *Feb. 13, 1967*), so why does it *suddenly* make you fall? (If your pupils can explain that a body falls when its center of gravity is no longer supported against the pull of gravity, skip to the next line starting with •.)

You can help your pupils grasp the concept of center of gravity by having them balance a flat-edged wooden ruler on a point, such as the point of a nail stuck through a cardboard base. Have them balance the ruler on each of its sides and each of its long edges. Each time it is balanced, push the ruler against the nail just enough to mark the point of balance.

Point out to your pupils that a line connecting the balance marks on the sides of the ruler and a line connecting the balance marks on edges would meet inside the ruler. The point where those two lines meet is called the center of gravity of the ruler; the pull of gravity is focused at that point, as if the ruler's weight were concentrated there.

By experimenting, your pupils can see that the ruler will fall unless its center of gravity is supported, that is, being pushed upward (away from the center of the earth) as strongly as gravity is pulling it downward.

- Have your pupils watch others trying to balance on one leg with their eyes closed and try to figure out where the center of gravity of the human body is located. (It is in the *pelvic*, or hip, region.)

- *How does your body keep balanced most of the time without your thinking about it?* When your body bends or tilts from an upright position, gravity changes the way the fluid and particles press on the nerve endings in your inner ear; your eyes see the floor, tables, sky, and so on at a different angle than when your head is upright; and bending in one direction stretches the muscles in the opposite side of your body.

These changes in your ears, vision, and muscles are continually being "reported" to your brain by tiny electric currents traveling through the nerves. Working like a computer, your brain keeps track of these changes and sends "instructions" via other nerves to certain muscles to tighten up and pull your body back into an upright position.

When your body bends slowly, it can keep your center of gravity over your feet. But if your feet suddenly slip out from under you, your body can't make the adjustment fast enough and you fall. *(Continued on page 3T)*

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nd science

VOL. 4 NO. 12 / MARCH 13, 1967

Does a ball bounce higher when it is hot or when it is cold?

see page 14

THAT'S THE WAY THE BALL BOUNCES

T THESE ANIMALS ON AN
EDITION TO NEW GUINEA
PAGE 2

TAR-FEEDING BAT

KO LIZARD

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CORRECTION: The cover photograph for the issue of January 9, 1967, was taken by M. W. Jennison, not the National Tuberculosis Association.

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A SCIENCE ADVENTURE

In the Land of Bikpela Rat Moa, Part 2

from MOUNTAI PEAK *to* SEASID CAVE

by Hobart M. Van Deu

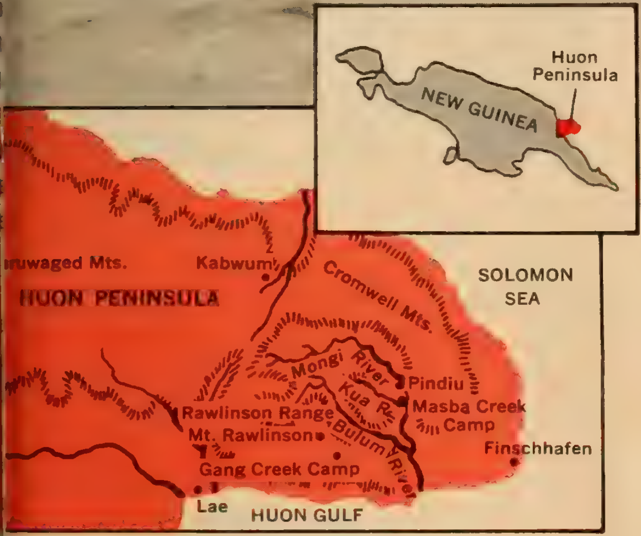
**In Part 1 of this article, the author told
he chose a team of men and prepa
equipment for an expedition to New Gui
Now, having arrived in New Guinea, the men
out to discover what kinds of anin
live in the rugged forested mountains
in the caves along the co**

■ We made headquarters for the expedition at the H
arium and Botanic Gardens in Lae, New Guinea. W
Ken MacGowan assembled our food supplies, Ru H
land, Stan Grierson, and I unpacked the crates and
ganized our gear. We arranged it in loads of diffe
weights. The load limit for one person was 40 pou

We discovered that the New Guinea women are m
used to carrying heavy loads than the men. The men
dom carry more than a spear or bow and arrows a
piece of sugar cane or sweet potato to eat along the t
The women all have big string bags, called "bilums," m
of plant fibers. In these bags the women carry all
of heavy loads, including drums of kerosene.

Soon it was time to leave for the mountains. The sin
engined airplane seemed like a toy beside our pile of b
and bags, but I was amazed to see how much gear coul
"shoe-horned" into it. Small airplanes have opened a
era of travel in New Guinea. Dozens of tiny airstrips
been carved out of the mountains. Now, patrol posts
once took days of walking to reach are within an ho
flight. Flying over New Guinea's rugged terrain is so
gerous, however, that flight plans are strictly followed,
pilots must make frequent flight reports, and no cra
allowed in the air after dark.

We had decided to make the village of Pindiu (*see m*
our mountain air base. Located in the heart of the H



insula, Pindiu is the center of a network of footpaths ding to the three mountain ranges we would explore ing the next six months.

hakedown" Camp at Pindiu

was on the last of the three flights needed to carry the edition to Pindiu. Our pilot flew east along the south st of the Huon Peninsula. This gave us a close-up view he Rawlinson Range, whose south slopes drop sharply n the summits to the shores of the Huon Gulf. The se forest on Mt. Rawlinson was unbroken by villages garden plots, and looked like a promising area to ex- re. Soon we saw the Mongi River, and turned inland ard Pindiu. A few minutes later we landed on the diu air strip, a shaved-off top of a ridge between two ll rivers, encircled by forested mountains.

Ve were met by a Patrol Officer and his wife who of- d us a "grass house" that had been their home until a few months before. Our house had a thatched roof and the outside walls were made of woven bamboo strips. One whole side was an open-air porch with a glorious view of the valleys and mountains. After moving in, we collected the snakes that lived in the roof of our home.

Pindiu was an ideal base and supply camp, but the area nearby was too disturbed by man to be good for our studies. Most of the forest had been cut down. We wanted to learn about the life of New Guinea's wild forests and grasslands. But Pindiu was valuable as a "shakedown" camp. We got to know each other and trained our crew in the work they would be doing for the next few months.

The mammals of New Guinea are most active at night. To collect bats, we set up *mist nets* (made of fine silk or nylon mesh), stretching them across paths and clearings where bats might fly. To collect other mammals, we set traps and also hiked the native trails at night, carrying a shotgun and wearing a hunting light (a flashlight head mounted on an elastic head-band, powered by a battery pack that snaps onto your belt). As we walked slowly through the forest, we swung the beam from tree to tree, from branch to branch. Soon we saw the light reflected from the eyes of a tree-climbing mammal. It is not a sporting way to hunt, but we couldn't easily get many of the New Guinea mammals in other ways.

(Continued on next page)

1

2

From Mountain Peaks to Seaside Caves (continued)

During an expedition we cover hundreds of miles of trails at night. It is a strange and exciting experience. Every sense is attuned to the surroundings. Sometimes roosting birds and hunting tree-snakes are caught in the beam of our head lamp. Small bats fly by on the trail. Overhead we hear the muffled swish of the soft wings of giant fruit bats.

Let's turn our lights off and listen. There's the thud of fruits dropped by feeding bats, the chorus of frogs, leaves rustling on the forest floor, the calls of night birds. As the weeks pass our ears gradually sort out these night sounds, but there are always some that remain a mystery.

A Typical Collecting Day

At Pindiu and at our next camp at Masba Creek (*see map*), we fell into the simple routines of a collecting camp. Each day we were up at daybreak to check our traps before the ants (many of which are active in daytime) nibbled at the trapped rodents and small marsupials. Then we removed bats that were caught in the mist nets, and lowered the nets for the day so that birds would not be caught. Each mammal collected was put into an individual plastic bag. Then wads of cotton soaked with ether were dropped into each bag to "knock out" (*anesthetize*) the fleas, ticks, and other parasites.

After this was done, we had breakfast—home-made bread, jam, tea, sometimes curried corned beef on toast, possibly even the scrambled eggs of bush turkey.

After breakfast, we went to work at the "skinning table." Each mammal was weighed, measured, and given a label and a number. Information such as the animal's name, number, weight, and measurements were recorded in two places—on the animal's label and in a special notebook. The parasites were collected and put into small bottles of alcohol (one bottle for each mammal specimen). Next each specimen was skinned and dusted with arsenic and alum powder (to preserve the skin). Then the skin was filled with cotton or *tow* (a fine hemp fiber), and sewed up and pinned out on a drying board.

This work sometimes took most of the daylight hours, depending on the number of mammals collected the night before. Then the traps had to be rebaited, mist nets raised into position, and new trap lines put out. We wanted to be ready for the short twilight of the tropics, for in this brief period bats hunted insects in the camp clearing. We tried to shoot the bats as they twisted and turned against the darkening sky.

Then we had dinner, a welcome meal after a tiring day. One evening we had delicious "snake steaks"—cut from a 12-foot-long python we had collected (*see photos*).

At nightfall or soon afterwards the forest is alive with feeding rodents and marsupials. This is the time for hunting the trails with shotguns and lights. It was often 11 P.M. or later when we returned to camp, so we just had time to collect the insects that were attracted to the lights and to jot a few notes in our expedition diaries before falling into our sleeping bags.

To the Top of Mt. Rawlinson

After two weeks at the Masba Creek camp, we returned to Pindiu to reorganize our supplies. Ken MacGowan hired a carrier line to take us on the three-and-a-half-day journey to Mt. Rawlinson. It takes less than 10 minutes to *fly* to Mt. Rawlinson from Pindiu; this may give you some idea of how tortuous the trail is. On the way to Mt. Rawlin-

ng the many unusual plants and animals the expedition d in New Guinea were: 1) huge acorns from oak trees photo shows their size compared with a nickel); 2) the us, a tree-climbing marsupial about the size of a cat; any kinds of bats; and 4) tree frogs.

son, we had to cross the Kua and the Bulum Rivers on swaying bamboo bridges.

On the morning of the fourth day we made camp, 4,500 feet up on Mt. Rawlinson and high above a rushing mountain brook (called Gang Creek). Men with hunting dogs offered to help us collect tree-climbing kangaroos and forest wallabies. This was a stroke of good luck because these marsupials are difficult to hunt in the thick mountain forest. We also trapped bandicoots, several marsupial "rats," and some unusual hopping rodents. (A New Guinea boy taught us how to catch these rodents in traps baited with large beetles.)

On one of the rare days when the summit of Mt. Rawlinson was free of clouds, Tobram, my assistant, and I climbed the long easy ridge that leads to the forest-covered 7,300-foot summit of Mt. Rawlinson. According to our local guide we were the first "outsiders" to reach this peak. We saw many signs of *cassowaries,* which are large, flightless birds. They are so wary that in all my years in New Guinea I have never seen one in the wild.

In the Land of Giant Rats, Fleas, and Water Rats

The Gang Creek camp was a successful one, and we returned to Pindiu with a feeling of solid accomplishment. Ru Hoogland then took a small carrier group and set off to make a camp near the high peaks of the Cromwell Mountains. MacGowan, Grierson, and I followed, and after five days of carrying we reached the camp. We were at the edge between forest and grassy plain, about 7,800 feet above sea level. I will always remember this camp for its giant rats and their fleas, and for the beautifully furred water rats that Stan Grierson discovered.

(Continued on the next page)

At the camp on Masba Creek, the biologists collected a 12-foot-long python *(below).* Kim, the camp cook *(right),* made a meal of the python after cutting it into "snake steaks."

One night at dusk he was shooting bats near the Mongi River where it ran in a series of quiet pools at the edge of the grassland. He noticed something break water in the nearest pool. As he watched, a water rat surfaced and then swam to the bottom of the pool. He fired the next time it came up for air, but unfortunately the rat drifted away just out of reach and was lost in the darkness downstream. Next evening we were better prepared, and by the end of the week we had collected several of these water rats. Only a few of these animals had ever been captured; in fact, they have no common name, but their scientific name is *Crossomys*. Never before had any biologist watched this animal alive, swimming and diving in its river habitat.

Ru Hoogland left to make camps in the sub-alpine and alpine zones of the Saruwaged Mountains. He was joined a week later by Ken MacGowan and by a botanist from Canberra, Australia. They explored the Saruwageds for several more weeks, collecting and studying the plants of the mountain peaks. Meanwhile, Stan Grierson and I hiked to the patrol post of Kabwum. From there we radioed for a charter plane to carry plant and mammal specimens back to Lae.

Rumors of Caves on the Coast

We had heard that there were caves at the east end of the Huon Peninsula (*see map at beginning of article*). If the caves were there, we wanted to find out what kinds of bats lived in them. So, Stan Grierson and I found a small ship bound for the coast near Finschhafen, and by the next morning we were staying in a small house on the shore of the Solomon Sea.

A man offered to guide us to a nearby cave that ran completely through a limestone ridge near the coast. He led the way down to the bed of a small stream that soon disappeared into the mouth of the water-worn cave. Several hundred feet into the cave, we came upon a high-ceilinged, dimly lit chamber. We surprised dozens of "flying foxes" (big, fruit-eating bats) that flew out the far entrance.

The flying foxes and other bats roosted in this cave, and we collected some of these mammals. We also photographed the other life of the cave—whip scorpions, cave crickets, fresh water crabs, and even a young black-headed python that we saw crawling across the rough ceiling of one of the tunnels.

Word came of another cave a few miles down the coast. We waded through a sago palm swamp and, after squeezing through a narrow entrance, we found a beautiful chamber with its ceiling covered with odd-shaped stalactites. There were even more bats here than in the first cave.

Our time in the field soon ran out. The "team" reassembled in Lae to pack all the specimens we had collected. The end of an expedition is only the beginning of further studies that may take years to complete. The specimens we collected are now being studied by many scientists in various parts of the world. This expedition has brought us one step closer to our main goal—to find out what kinds of plants and animals live in one of the strange corners of our world. But many questions remain unanswered. Will we return? Yes, as long as we have curiosity, we will always return! ■

The left photo shows the author (wearing head lamp) collecting scorpions in a cave near the coast of New Guinea. Fruit-eating bats, called flying foxes *(above)*, were also found in this cave.

How do your eyes help you keep your balance?

by George Barr

■ In our everyday contact with modern electronic miracles, we often forget what remarkable mechanisms our own bodies contain. For example, our sense of balance depends upon teamwork of many parts of the body.

We stand erect because muscles all over our body are constantly correcting our upright position. If you think about it, you can almost feel your foot, leg, and thigh muscles relaxing and tightening. Doctors say that muscles can "sense" an unbalance and automatically adjust our posture. Learning to walk as a child consisted partly in training these muscles.

The main balancing organs are in the nonhearing part of our ears. In each ear we have a *semicircular canal (see diagram of the human ear in "The Not-So-Silent World,"* N&S, *October 13, 1966).* This consists of three looped tubes, each at right angles to the other two. These loops are filled with fluid and lined with nerve cells going to the brain. A movement of the body in any direction causes the proper muscles to move to keep us balanced.

In each ear we also have tiny, loose, solid particles. When the head is tilted, gravity causes these to touch ends of nerves leading to the brain.

But you probably do not realize how important your eyes are for balancing until you do the following experiment. Keep your eyes open and stand on one foot. Unless you are a nervous wreck, this is fairly easy to do.

Now close your eyes and stand on one foot. See how many seconds you can do this apparently simple stunt. Suddenly you realize that there is something wrong. Without your eyes to give you clues, all your other priceless balancing machinery in your ears and brain seem to be out of order. Yet as soon as you open your eyes you are again master of the situation.

What Will Help You Balance with Eyes Closed?

Try many schemes to help you keep your balance on one foot with your eyes closed. Before you close your eyes look closely at a strong light. Does the lingering light impression in the eye help you in any way? Try bending the leg you are standing on to lower your center of gravity. Twist your foot or your body to find a more stable one-legged position. Keep track of your position by standing close to a source of sound. These ideas may not work, but they are the kind of experimentation you should try.

Can you train yourself, after a while, to stand erect on one foot? Do you get the same swaying effect when you stand for several minutes on both feet in the dark? Do tightly laced shoes help? Try this balancing stunt in the early morning or late at night. Does it make any difference whether you are tired or fresh?

Keep records of the number of seconds you can count off each time. Do you find that certain people can do this better than others? Ask these people if they ever get dizzy, seasick, or carsick. It may be that people who can stand on one leg with their eyes shut have more stable nervous systems as far as balance is concerned ■

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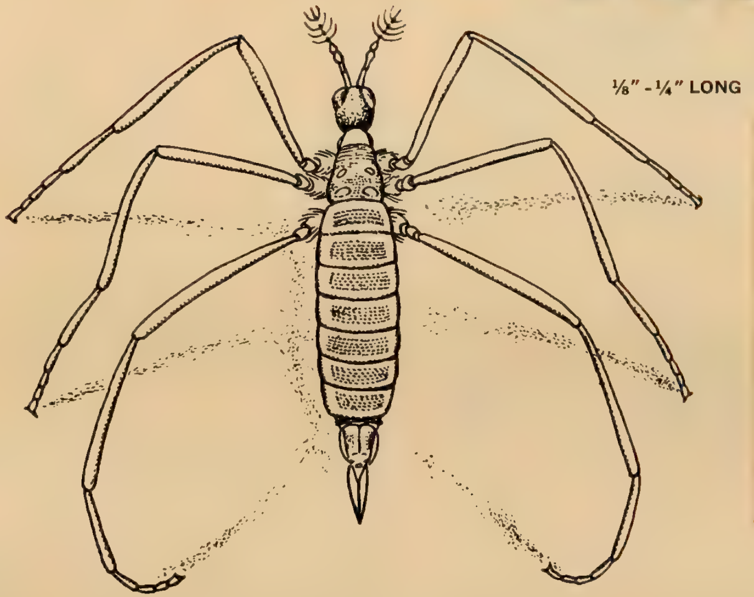
insects of the snow

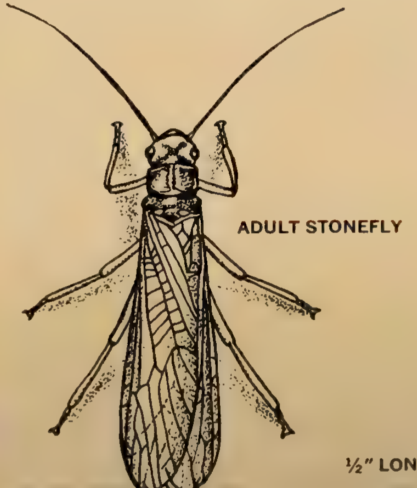
■ Have you ever seen a swarm of insects on the snow? You might, if you look in almost any woods where there is still snow but the temperature is a little above freezing. In fact, there are several kinds of insects that you will probably find *only* on snow.

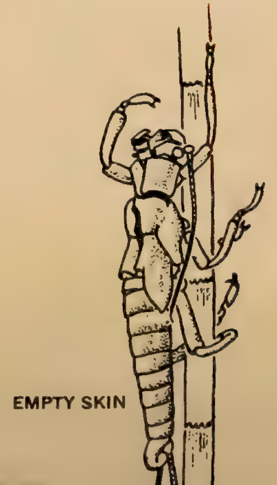
Snow insects are small, but often gather in dense swarms. Their dark color and lively movements make them easy to see against their white background. It is easy to overlook them, but you can find them if you try. The common kinds belong to four great groups, or "orders," of insects —the true flies (*Diptera*), the scorpion flies (*Mecoptera*), the stone flies (*Plecoptera*), and the springtails (*Collembola*).

Not much is known about the lives of snow insects. You might learn something new to science by watching these animals. The drawings on these pages will help you identify the most common snow insects when you find them. —ALICE GRAY



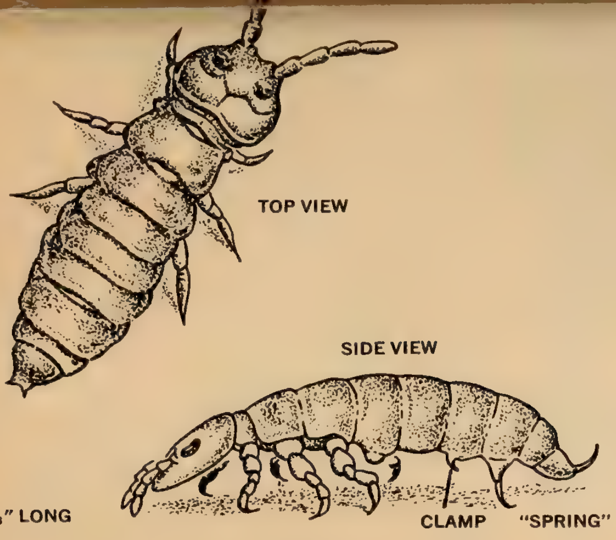
The snow fly (*Chionea*) belongs to the true cranefly family (called the Tipulidae). It has long legs like other craneflies, but is wingless. It cannot "dance," but "staggers" over the snow, "like a clumsy spider" as one scientist described it. After mating on the snow, the females lay their eggs in the earth below.





Young stoneflies live in swift-flowing water. When ready to mature, they climb out of the water, then struggle out of their skins for the last time. You may find these empty skins attached to stones, tree trunks, and other objects along streambanks. Many kinds of stoneflies mature in winter and come out of the water through cracks in the ice.

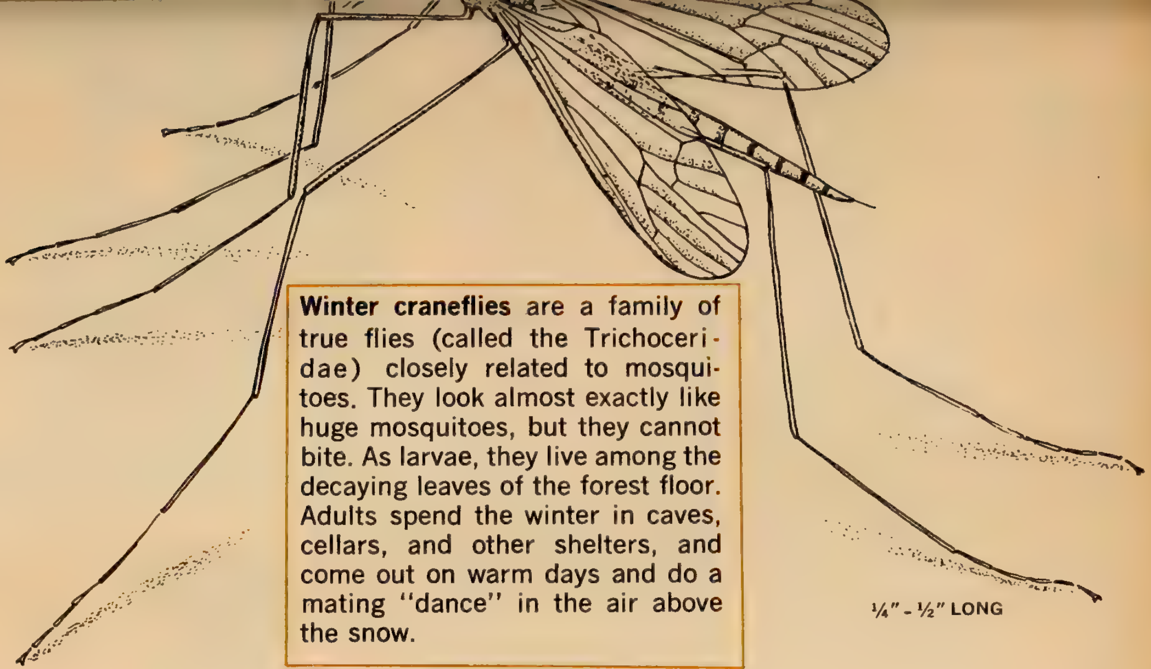
Although stoneflies have large wings, they fly poorly and are seldom seen far from water. Look for them on bridges, tree trunks, stones, and snowbanks along streams. They are big for winter insects—some reach a length of half an inch. But when sitting still they look so much like rolled bits of dead leaves that they are hard to see.



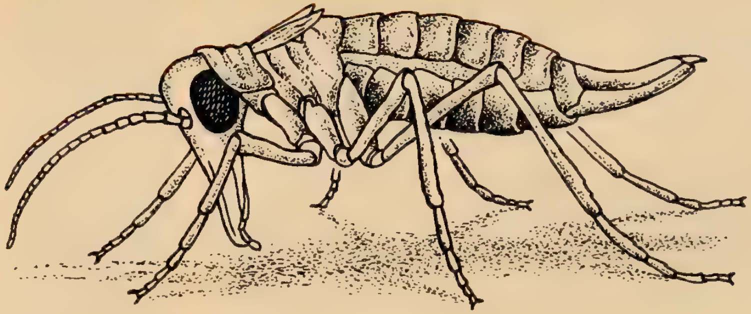
Commonest and most widespread of winter insects are the snow fleas, which hop like fleas but are really members of the order of insects called springtails. A snow flea has a forked "spring" underneath its body that is bent forward and held fast by a clamp in front of it. When the clamp lets go, the spring straightens out and strikes the ground with enough force to fling the insect many times its own length. Snow fleas are tiny, so four inches is a long jump for the best of them.

The snow flea that you are most likely to see is a dark blue kind about an eighth of an inch long. It swarms in countless millions so that the snow is blackened for yards around the place where the insects come up through a crack in the snow. Snow fleas live in rotten logs and other wet spots where there is plenty of decaying plant material. You can find them at any time of the year; they probably swarm whenever their food supply is exhausted and the weather is damp enough. (Cold bothers them very little but they die quickly if they dry out.)

During a thaw, the air above the snow is full of water vapor. The hungry snow fleas come up from beneath the snow and scatter to find a fresh food supply. By the next day almost all of them will have disappeared..



Winter craneflies are a family of true flies (called the Trichoceridae) closely related to mosquitoes. They look almost exactly like huge mosquitoes, but they cannot bite. As larvae, they live among the decaying leaves of the forest floor. Adults spend the winter in caves, cellars, and other shelters, and come out on warm days and do a mating "dance" in the air above the snow.

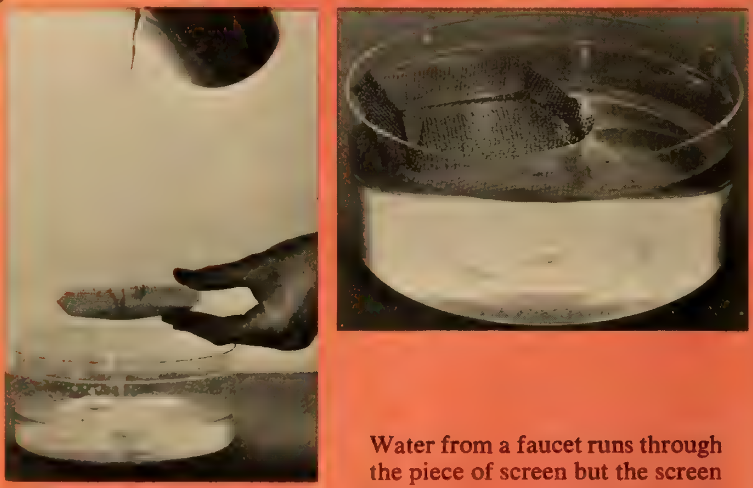


Another group of snow-runners are the species of *Boreus*, the snow scorpion flies. Scorpion flies get their name from the scorpion-like shape of the abdomen in males of some species (but not in *Boreus*). *Boreus* does have the scorpion fly head—big-eyed, with little chewing mouthparts at the end of a long "beak." It seems to be wearing a gas mask.

After the scorpion flies mate on the snow, the females lay their eggs in cracks in the earth. The larvae that hatch from the eggs look somewhat like caterpillars (but they have no "legs" on the abdomen). Staying underground, the larvae probably feed on tiny living animals in the soil—but no one knows for sure. Once the larvae develop into pupae, they may spend the rest of the year underground, to emerge as adults when the snow melts the following spring. Again, no one knows for sure.

BRAIN-BOOSTERS

BY DAVID WEBSTER



Mystery Photo

Water from a faucet runs through the piece of screen but the screen floats. How do you explain this seeming contradiction?

Fun with numbers and shapes

Which would give you more juice, three oranges that were 2 inches in diameter, or one orange measuring 3 inches in diameter?

Just for fun

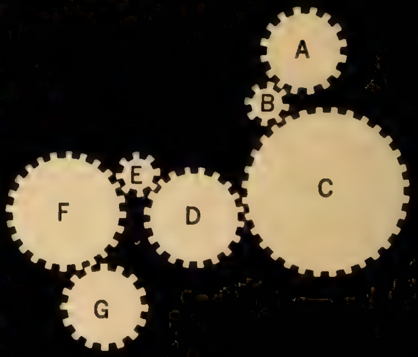
How much dirt can a seed grow through? Plan seeds at different depths and find out. Car some kinds of seeds get through more dir than others?

Can you do it?

Can you fold a piece of paper in half nine times? Try very thin paper or an extra large sheet. *Submitted by Mark Lehr, Reed City, Michigan*

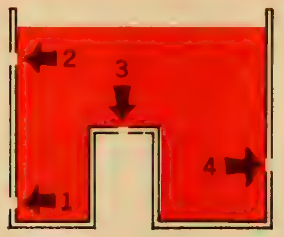
For science experts only

If Gear A is turning around three times per minute, how fast is Gear G turning?



What would happen if?

The odd-shaped can has four small holes marked by the arrows. Out of which hole would the water squirt fastest?



ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

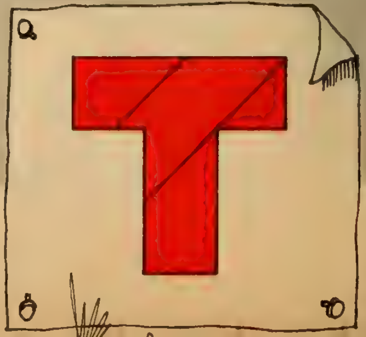
Mystery Photo: The circular marks in the sand were made by the beach grass as it was blown back and forth by the wind.

Can you do it? Water will not mix with kerosene, car oil, or salad oil. Can you find *three* liquids that will stay in separate layers?

What would happen if? When the candle is spun around, its flame will lean in toward the center.

For science experts only: To find the weight of one page in a telephone book, divide the weight of the book by the number of sheets.

Fun with numbers and shapes: Here is how to arrange the four shapes to make a "T".



Like mariners of old, this yachtsman sailed his Chinese junk into shallow water, waited for the tide to flow out, then tipped the junk so he could scrape barnacles (and other shellfish and worms) from the teakwood hull. The drag of these sea animals against the water slowed the junk down when it was sailing or being propelled by an outboard motor.

Hitch-Hikers of the Sea

by Steven W. Morris

Barnacles sticking to a ship's bottom can slow it down so much that the bottom has to be scraped every few years. Scientists are looking for ways to keep these unwanted passengers from gluing themselves aboard for life.

■ You may think of barnacles only as crusty animals that are stuck on sunken ships. Or, if you have been to the sea shore, you may have seen some barnacles attached to a rock or the wooden supports of a pier. How these animals stick so tightly is a mystery scientists are trying to solve.

Barnacles often take life-long free rides on turtles, crabs, and whales, as well as on the bottoms of ships and boats. When a lot of barnacles attach themselves to the bottom of a ship, they make it heavier and rougher, slowing the ship's motion through the water. The ship's engines have to work harder, and they may use up three tons of fuel to move the ship the distance it was moved on two tons of fuel before the barnacles covered the bottom.

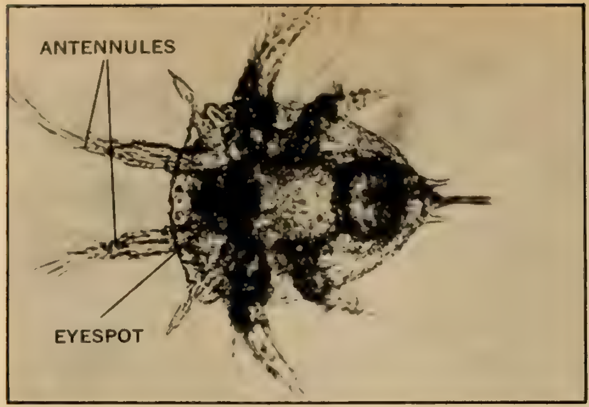
When ships were built completely of wood, the bottom was often covered with a "skin" of copper, which is poisonous to barnacles. But when shipbuilders began to make hulls of iron, about 100 years ago, they found that if copper touched the iron it made the iron rust much faster. So copper coatings couldn't be used to protect the hull from barnacles.

Later, shipbuilders found that a combination of copper and oxygen called *cuprous oxide* poisons barnacles but doesn't make iron rust faster. Today most paint for boat and ship hulls contains cuprous oxide. But even this doesn't solve the problem completely. Within about two years, the sea water has dissolved the copper out of the paint, and barnacles again can survive on the hull. This means that ships have to be taken out of the water every two years or so to have the barnacles scraped off and the bottom repainted.

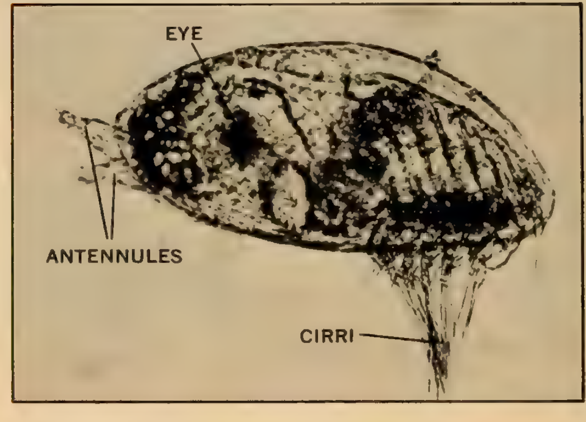
The Life of a Barnacle

When an acorn barnacle hatches it looks something like a tiny crab that you can see partway through *(see photo on next page)*. A hundred of them lined up would be only

(Continued on the next page)



In its six larval stages, a young barnacle looks like a tiny crab. Its *antennules* and other leglike parts help in swimming. The barnacle in this photo is in its fourth larval stage and is shown about 100 times its actual size. Scientists can tell how healthy it is by observing the movements of the organs and waste materials inside the larva.



A barnacle in the cyprid stage uses its two gluey "feet," or *antennules*, to pull itself over solid surfaces. *Cirri*, or "hairs," near the back end help in swimming. When the barnacle becomes attached in one spot and begins to grow a new shell, the cirri fan the water to make currents that bring food to the barnacle.

Hitch-Hikers of the Sea (continued)

about an inch long. As the barnacle grows, it sheds its shell six times, changing its form a little each time. Each of these *larval* stages lasts only one or two days.

After its sixth larval stage the barnacle changes into its *cyprid* stage *(see photo)*, and is shaped like a kidney bean. Its shell is now in two sections, like a clam's. Many "hairs" at one end help the cyprid swim. Two stubby "feet" at the other end help in "walking." A glue-like substance from a gland forms drops on the end of the feet. The cyprid touches a gluey foot to a rock, pulls itself forward, then lifts its foot off the rock. After a few hours or a day, the glue gets so hard that the foot can't be pulled back up, and the barnacle is stuck in that spot for the rest of its life. It turns into an adult barnacle and from then on its body keeps forming more shell plates, one over the other. The barnacle lives by straining small creatures from the surrounding water. Its hairs stick through a hole in the shell and fan the water, causing currents that bring food toward the hole.

A Barnacle Farm

Scientists figured that if they could find a way to keep the cyprid from attaching to ships, their hulls would not have to be repainted so often. United States Navy scientists who wanted to test anti-barnacle paints decided they needed to make their tests in a laboratory. There they would be able to examine the barnacles closely and to control everything about the water the animals lived in—its movement, temperature, saltiness, and the number and kind of barnacles in it. But no one had ever before been able to raise and keep healthy in a laboratory the large numbers of barnacles that would be needed.

The head of a team of Navy scientists, Arnold Freiberger, said barnacles are rather delicate creatures, and it doesn't take much to kill them off. Mr. Freiberger's team set up their laboratory at the New York Aquarium in Brooklyn. One kind of acorn barnacle grows on rocks at Coney Island beach near the laboratory, and the scientists scrape them off with knives. But these barnacles hatch only once a year. To give the laboratory a year-round supply of hatching barnacles, the scientists have to send to Florida.

There, in the warm waters of Biscayne Bay, live four other kinds of acorn barnacles that hatch all year round. Aluminum plates lowered into the bay become covered with these barnacles *(see photo)*. The plates are taken out and wrapped in wet paper, and flown to the Navy laboratory in New York the same day. The scientists scrape the barnacles off and send the plates back to Florida.

Straining Out the Barnacles

"We found that barnacles grow faster on the used plates that have a little of the shell left on than they do on new plates," said Christopher P. Cologer, an engineer on the Navy team. "This tells us something about the kind of surface that's best for growing them."

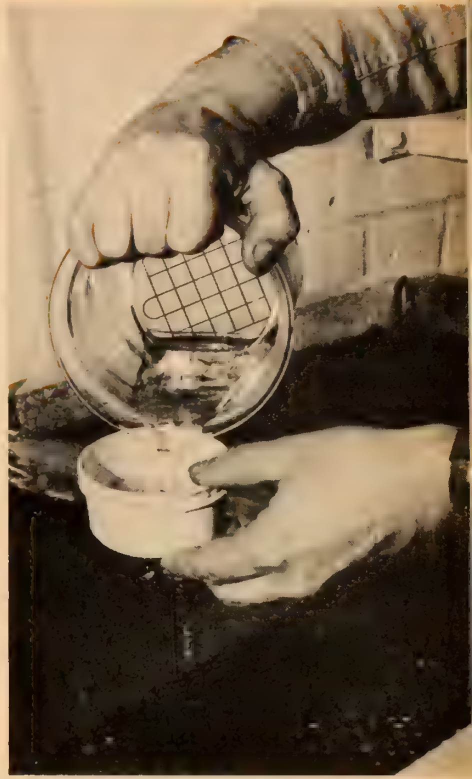
Like other experimenters, the Navy scientists at first tried to keep the water the barnacles were kept in clean and fresh by running a steady stream of water through the containers.

"This didn't work," Mr. Cologer said. "We always got a buildup of algae (tiny sea plants) and waste products that fell to the bottom. Bacteria grew fast. So we tried raising barnacles and separating them from the unhatched eggs and waste products by pouring the water they lived in through metal sieves. Those barnacles didn't stay healthy. Maybe the small amount of metal that dissolved into the water from the sieves poisoned them."

To avoid this the Navy scientists made sieves out of paper cups and cloth *(see photo)*. First they cut the top parts off two paper cups. Then they wrapped a piece of fine mesh cloth around the bottom of one of the cup tops and squeezed this into the other cup top, so the cloth was held tightly in place. Using this strainer, the scientists can transfer the barnacles to fresh jars of water as often as they wish (at least once a day) without losing any or poisoning them. When the barnacle eggs hatch, the new barnacles can easily be separated from the unhatched eggs and adults.

Finding food for the barnacles was another problem. The one-celled plants the team first fed them measured 25 to 50 microns. (Twenty-five microns is about one-thousandth of an inch.) These cells were large in comparison to the cyprid-stage barnacles, which measure 180 to 600 microns. The scientists saw that the barnacles were eating much less food than they needed. The activity of their bodies was slow. The scientists wondered if feeding the barnacles smaller plants would work better. They got 17 smaller kinds of plants, some of which measured three to eight microns. One kind out of the 17—*Cyclotella nana*—worked. The newly-hatched barnacles could eat it, grow through all their stages, and then reproduce new barnacles.

These barnacles attached themselves to the aluminum plate in Biscayne Bay, Florida, and were flown to the Navy laboratory in New York. There they are scraped off and put into water to produce new barnacles for scientists to study.



A finely-woven cloth held between the tops of two paper cups catches tiny barnacles as water is poured through it. A metal sieve seemed to affect the barnacles, which may have been poisoned by metal dissolved from the sieve.

Having healthy barnacles in the laboratory paid off right away in new knowledge. The scientists found, for example, that barnacles are not poisoned by cuprous oxide when they are in the cyprid stage. Barnacles in that stage do not eat, so cuprous oxide can't get inside them. After the barnacle turns into an adult, it begins feeding again and can be poisoned by cuprous oxide. It dies, but its shell remains attached to the hull.

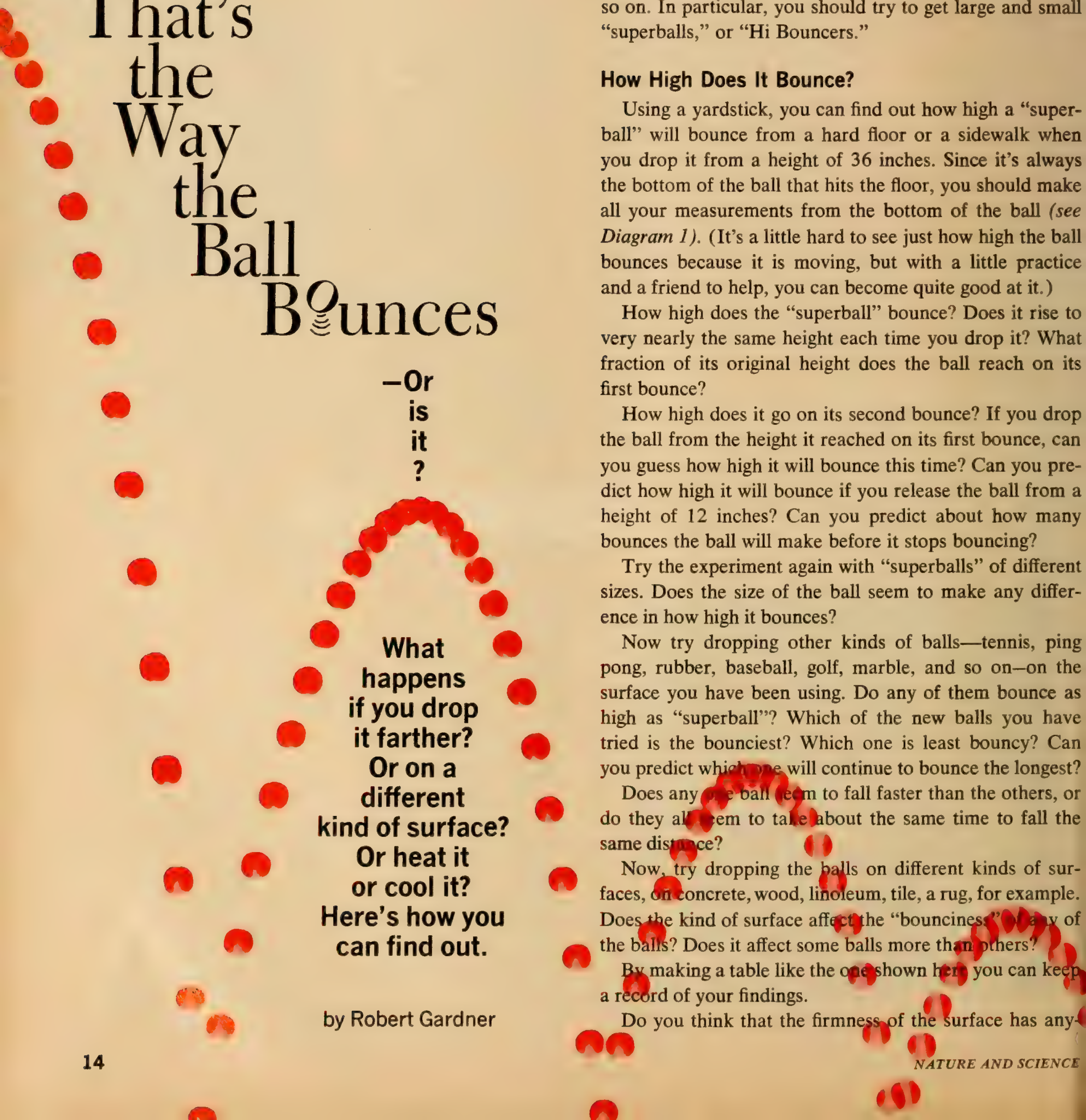
How Does It Stick?

If scientists can find out what the little drops of glue are made of, they may be able to find something the glue won't stick to. Is the glue still made after the barnacle is attached? How much of the barnacle's sticking power is caused by the glue, and how much by the shell? So far these are still mysteries.

Will sound vibrations *(see* N&S, *October 17, 1966)* keep barnacles from attaching themselves to ships? Will magnets do it? Or making the ship's bottom very smooth or very rough?Navy scientists have noticed that barnacles are affected by light: The larvae swim toward a strong light, and a cyprid lines itself up in the direction of a strong light when it attaches itself to a plate. Maybe this will be the clue that helps scientists find a way to rid ships of barnacles forever. Or maybe the clue will come from something no one has even thought about so far ■

That's the Way the Ball Bounces

—Or is it?



What happens if you drop it farther? Or on a different kind of surface? Or heat it or cool it? Here's how you can find out.

by Robert Gardner

■ Can you guess how high a ball will bounce when you drop it on a hard surface? Does the height depend on how far the ball falls? Does it depend on the kind of ball or the size of the ball you drop? Does the kind of surface you drop the ball on make a difference? Will the temperature of a ball affect its bounciness? Can you predict how high the ball will rise on the second or third bounce?

Here are some ways that you can investigate bouncing balls and find some answers to these questions. The first thing to do is to gather several different kinds of balls—tennis, baseball, ping pong, a marble, rubber ball, and so on. In particular, you should try to get large and small "superballs," or "Hi Bouncers."

How High Does It Bounce?

Using a yardstick, you can find out how high a "superball" will bounce from a hard floor or a sidewalk when you drop it from a height of 36 inches. Since it's always the bottom of the ball that hits the floor, you should make all your measurements from the bottom of the ball *(see Diagram 1)*. (It's a little hard to see just how high the ball bounces because it is moving, but with a little practice and a friend to help, you can become quite good at it.)

How high does the "superball" bounce? Does it rise to very nearly the same height each time you drop it? What fraction of its original height does the ball reach on its first bounce?

How high does it go on its second bounce? If you drop the ball from the height it reached on its first bounce, can you guess how high it will bounce this time? Can you predict how high it will bounce if you release the ball from a height of 12 inches? Can you predict about how many bounces the ball will make before it stops bouncing?

Try the experiment again with "superballs" of different sizes. Does the size of the ball seem to make any difference in how high it bounces?

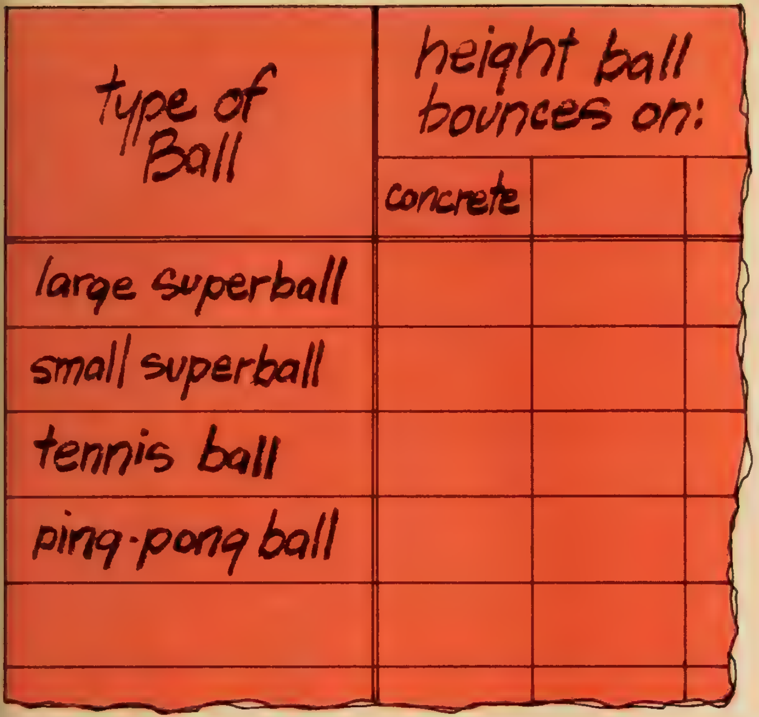
Now try dropping other kinds of balls—tennis, ping pong, rubber, baseball, golf, marble, and so on—on the surface you have been using. Do any of them bounce as high as "superball"? Which of the new balls you have tried is the bounciest? Which one is least bouncy? Can you predict which one will continue to bounce the longest?

Does any one ball seem to fall faster than the others, or do they all seem to take about the same time to fall the same distance?

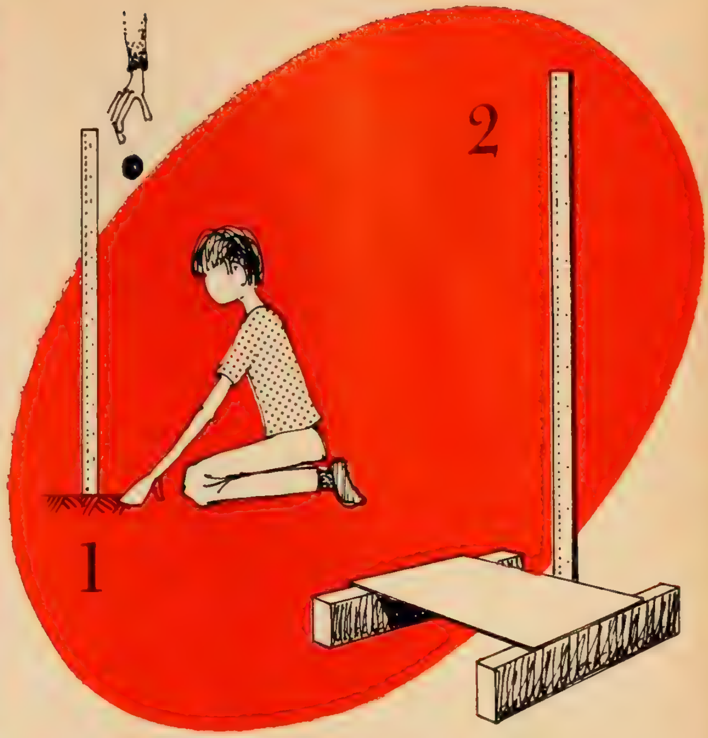
Now, try dropping the balls on different kinds of surfaces, on concrete, wood, linoleum, tile, a rug, for example. Does the kind of surface affect the "bounciness" of any of the balls? Does it affect some balls more than others?

By making a table like the one shown here you can keep a record of your findings.

Do you think that the firmness of the surface has any-



type of Ball	height ball bounces on:		
	concrete		
large superball			
small superball			
tennis ball			
ping-pong ball			



thing to do with how high the ball bounces from it? To find out, drop the ball on a wooden floor and then on a thin piece of wood with its ends resting on pieces of wood *(see Diagram 2)*. Try this with big and small "superballs" as well as some of the others, and compare how the different kinds of balls bounce on the two surfaces. Can you think of any explanations for your results?

Hot and Cold Bounces

Do you think that changes in temperature will have any effect on the "bounciness" of any of the balls?

To find out, you can record first how high the balls bounce at room temperature just as you have done before. Then put the balls that you want to test into the freezing compartment of a refrigerator. (If it is very cold, you can place them outdoors.) Heavy balls will take longer to lose their heat than the lighter ones, but an hour should be long enough to cool them. After they are cooled, remove one ball at a time and quickly—before it starts to warm up—determine how high it bounces.

Do the cooled balls bounce higher than they did at room temperature? Lower? The same?

To warm the balls, you might ask your mother—or your teacher, if there is a stove in your school—to help you heat the balls in an oven where you can control the temperature. If you do this, be sure to use tongs to grip the heated balls so that you don't burn your hands. Remove one ball at a time, and test it before it cools.

Are any of the balls bouncier or less bouncy than they were at room temperature? What happens to their bounciness as you heat the balls to higher temperatures, say up to 350°F? When the balls cool back to room temperature, is the bounciness of any of them different than it was before? Does it stay that way? ■

MORE INVESTIGATIONS

1. How can you get a ball to bounce higher than the height from which you release it? With which ball is this easiest to do? Are there any balls with which you can't do this?
2. What things can you do to make one of the other balls bounce higher than "superball"?
3. Besides bounciness, in what other ways does "superball" differ from the other balls? For one thing, try *sliding* "superball" along a smooth surface. How does the friction between "superball" and the surface compare with the friction of the other balls on the same surface? *(see "Measuring Friction,"* N&S, *Dec. 19, 1966).*
4. Roll a piece of clay into the shape of a ball and drop it from a height of 36 inches. How high does it bounce? Can you find a flattened out area on the clay ball after it has hit the floor? What caused it? Do you think the other balls you have dropped get flattened a little as they hit the floor? If so, why don't they stay flattened? Do you think you can explain the difference between the bounciness of clay and the other balls?

HOW IT WORKS

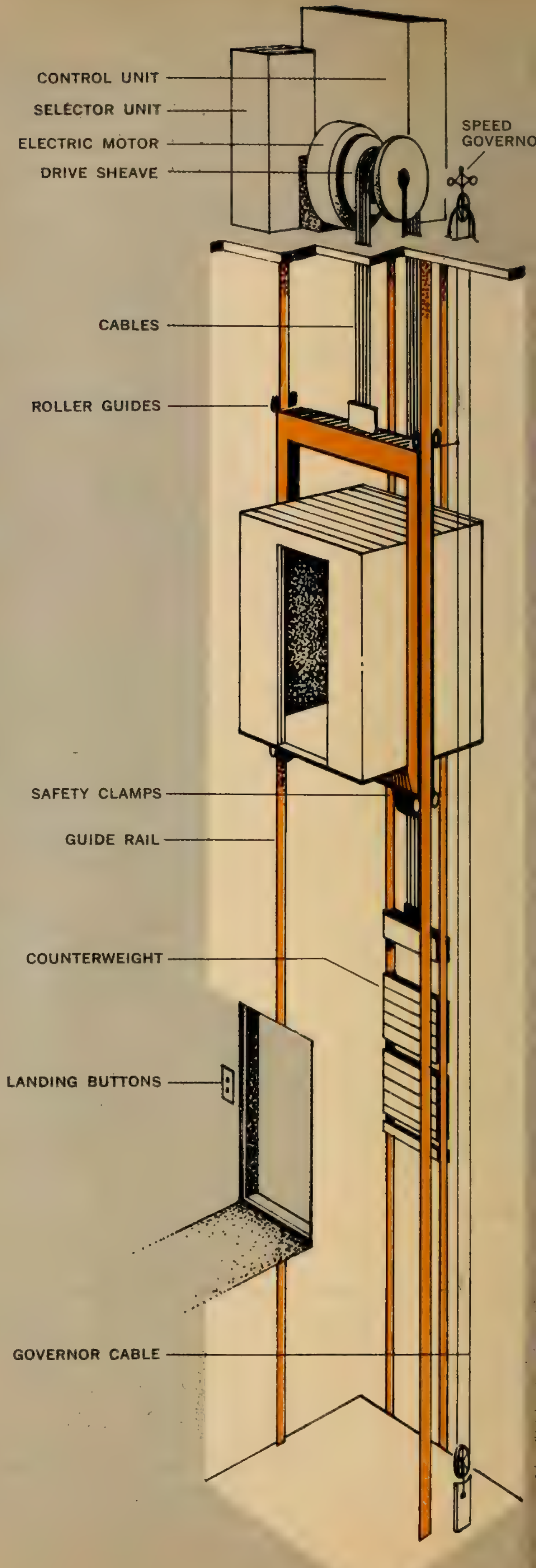
Automatic Elevator

■ An elevator is raised and lowered by an electric motor that turns a grooved wheel, or *drive sheave,* at the top of the elevator shaft. Steel cables run from the top of the car up the shaft, over the sheave, and down the back of the shaft to the *counterweight*. The counterweight balances the car and its load, so the motor does not have to lift all of the car's weight. The downward pull of the car and the counterweight keeps the cables pressed tightly against the sheave so they will move when the sheave turns. The car and counterweight have *roller guides* that run along the *guide rails* on the walls of the shaft.

To use the elevator, passengers press the up and down buttons at each floor landing or the numbered buttons inside the car. The landing and car buttons are connected by wires to the *selector* and *controller* at the top of the shaft. These electrical units act as a kind of computer that "remembers" all passenger calls and controls the movements of the elevator until the calls are answered.

As the elevator moves up in the shaft, it stops automatically when it reaches each floor where a passenger has pressed the up button or for which someone has pressed the button in the car. When the elevator has answered the highest call, it automatically reverses and then stops at the floors where people have pressed the down buttons.

A cable attached to the side of the car turns the *speed governor* at the top of the shaft *(see diagram)*. If the governor turns too rapidly, its "arms" spread outward and throw a safety switch that sets the brake on the drive sheave. If this brake fails to stop the car's rapid drop, the governor grips the *governor cable*. This makes *safety clamps* on the car spring out and wedge against the guide rails, bringing the car to a slow stop ■



Suggestions for Using BRAIN-BOOSTERS

Brain-Boosters are science and math puzzles designed to make children think. Here are some ideas that you can use to encourage your students to do this.

One thing you can do is to pick out a problem and have everyone work on it in class. For example, you could try the paper folding question in the Brain-Boosters this issue. Give out sheets of paper and let the children try to fold them in half as many times as they can. When they fail, some will suggest using a larger or thinner piece of paper. If you have some sheets of newspaper and tissue paper available, the children could then try these.

It is nice to have some activities like this ready to use in those short, sometimes useless time periods between gym and lunch or near the end of a rainy day.

Some of the Brain-Boosters are more suitable for demonstrations. In this issue, the Mystery Photo shows how a little boat made of window screening will float even though a stream of water goes through it. You could show your class how this happens by using a scrap of screening from a hardware store. The fact that there is something unique about the surface of the water *(surface tension)* can be demonstrated by showing how the screen will sink once it is pushed just beneath the surface.

The question on the oranges would be too difficult for most children to solve with mathematical formulas, but you could find the answer by using balloons and a large-mouthed jar that is partly filled with water. First, blow up three balloons so their diameters are two inches. Push them all the way into the water and mark how high the water rises. Then do the same thing with a three-inch balloon. You could also measure the volumes of other objects in the same way.

Some teachers use one of the Brain-Boosters from each issue of *Nature and Science* for a class contest. They might select the question about the odd-shaped can of water or the one on gears. The students could have a week to write their answers and deposit them in a special cardboard box.

If you have a folder on each science unit that you teach during the year, you could cut up the Brain-Booster page and file the problems in the appropriate place. The question on the odd-shaped can would apply to the study of water pressure, and the one on gears to a simple machine unit.

More important than the answers to Brain-Boosters are the methods and thought used in attempting to solve them. Since thinking usually ceases when the solution to a problem is known, the answers for Brain-Boosters are not given until the following issue. In many cases, however, you and your pupils can solve Brain-Boosters on your own.

—David Webster

A Style of Understanding

(continued from page 1T)

able through the application of elemental processes which are themselves accessible to everyone. This at once rejects the notions that scientists are different from the main stream of humanity or that scientific knowledge is unlike other knowledge.

- The working conviction that through analysis (the separation into constituent parts) and synthesis (the combination of parts to form a whole) comes understanding.

- The belief that quantitative assessment adds dimensions to understanding which are always difficult and sometimes impossible to achieve by other means.

- The tolerance which permits acceptance of all reasonable, testable hypotheses which are consistent with available evidence.

- A healthy skepticism even toward conclusions by existing evidence.

- The humility that follows the realization that scientific understanding comes by excising from the unknown the false alternatives, never by proposing a "truth."

- The confidence to admit "I do not know," based on the belief that there is a way to find out.

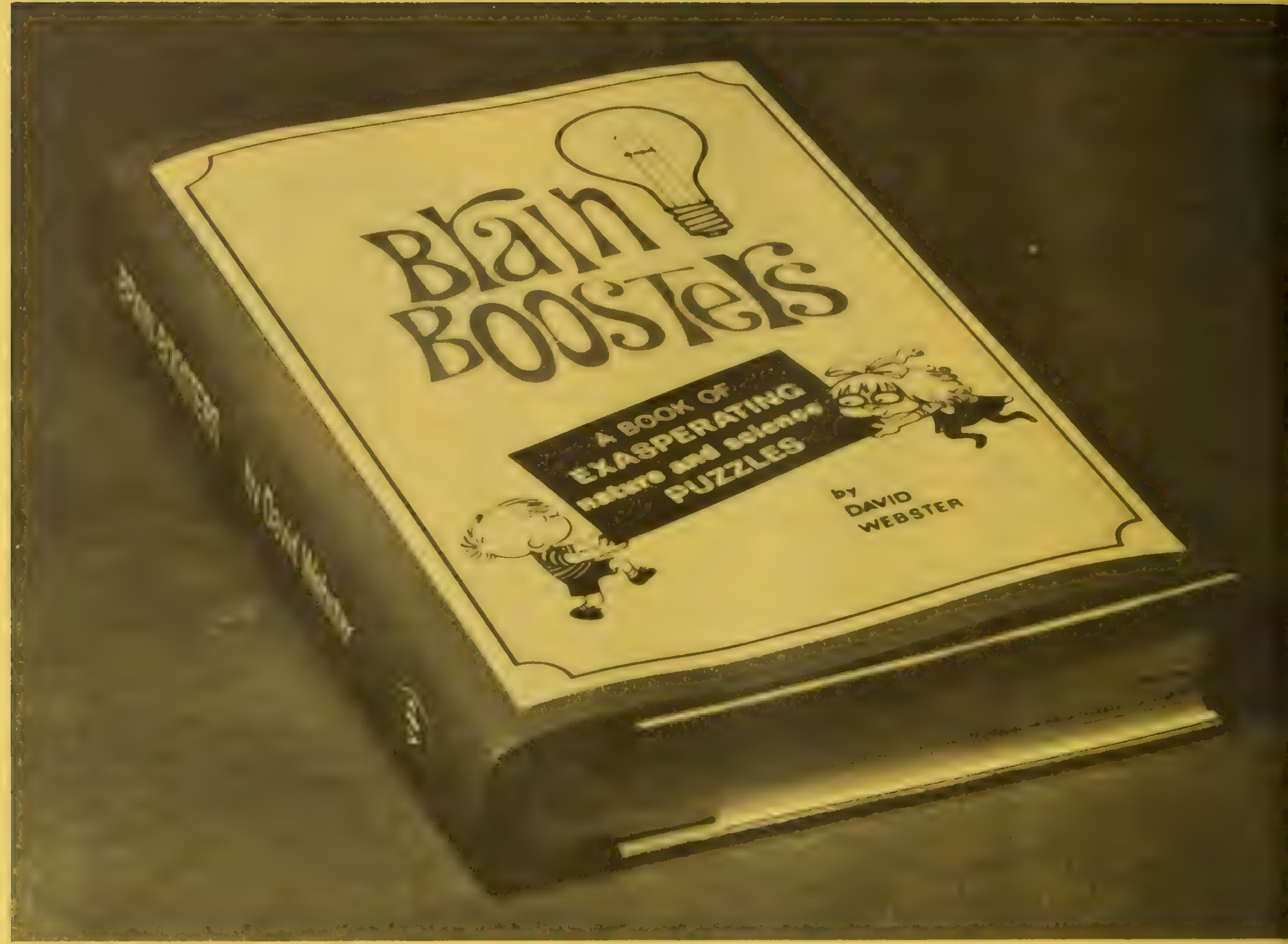
- The appreciation that to understand, while a means to power, is a joy and an end in itself.

If your reaction to this listing is "So what's new; we want that from all our teaching"—then you are with me. I agree, we do hope for such residual attitudes from all our teaching. But perhaps a reason for a somewhat limited success has been the emphasis in instructional time on the incredibly complex problems of the social sciences. The relatively simple structure of relevant problems from the natural sciences with mathematics may make the point as it has not been made before.

Philip Morrison (in the *American Journal of Physics)* has said it beautifully: "Less May Be More." His thesis is that much of the power of physics, and of sciences generally, is in the design of new questions and new experiments. A new emphasis is then necessary, Morrison believes, to get this idea to the ultimate target of children through the elementary teachers.

We have a wonderfully helpful lever to accomplish this because children at that period of life raise questions because they think it is fun. They neither have nor need any secondary motivation. As they grow older, however, this no longer holds true; and calculated action becomes necessary to prolong the desirable questioning attitude.

An attitude is not taught as a vocabulary list is memorized. Rather, it must be caught by the child through skillfully constructed sequences of activities and ideas, sparked by inspired teaching ■



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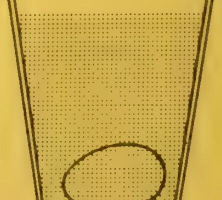
Author David Webster (known to NATURE AND SCIENCE readers as "Mr. Brain-Booster") is an elementary school science teacher now on the staff of Elementary Science Study of Educational Services Incorporated and a frequent contributor of articles to NATURE AND SCIENCE.

Permanent hardcover edition contains over 300 Brain-Booste
Some favorite ones from NATURE AND SCIENCE's famed "Brai
Boosters" pages—OVER TWO-THIRDS BRAND NEW!

If an egg is dropped into water it will sink. What can you do to make it float? (illustration) p.76



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nature and science

TEACHER'S EDITION

VOL. 4 NO. 13 / MARCH 27, 1967 / SECTION 1 OF TWO SECTIONS

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USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

"How Plants and Animals Reproduce" is the title of this special-topic issue, and some of the articles deal directly with the "how." Your pupils will probably recognize the similarities between reproduction in humans and in frogs or guppies. This may cause some giggles or snickers unless your school is one of a small number that have sex education classes as early as the middle elementary grades.

Giggles or not, the editors of *Nature and Science* suggest that you meet the subject head-on. Explain that humans are sexual beings just as frogs and flowers are. Since humans are mammals and primates, naturally their methods of getting gametes together and of developing young differ from the methods of other groups of animals. But human reproduction doesn't vary from the basic plan of life—the fusion of an egg cell and a sperm cell to form a new individual. You'll find additional helpful material for discussing human reproduction on pages 2T, 3T, and 4T.

The Significance of Sex

The first life on earth, perhaps two billion years ago, probably had *asexual* reproduction. These one-celled organisms reproduced by *fission* — the division of their genetic and cellular materials—with each half becoming an individual of the same kind. In asexual reproduction, the offspring are identical "copies" of the parent, unless a genetic change called a *mutation* occurs.

Asexual reproduction is still common in many groups of plants and animals *(see "How Plants Reproduce," page 2T)*. Some organisms have both sexual and asexual reproduction. Both methods are similar in the sense that a parent organism contributes a *part* of itself to a new individual.

The significance of *sexual* reproduction is that it is a device for promoting genetic variability and adaptation *(see the article, "From 'Blobs' to Lions")*. In sexual reproduction, the offspring cannot be identical "copies" of their parents, because the offspring have inherited characteristics from *two different* parents. Sexual reproduction *maximizes* variation in a species; asexual reproduction keeps variation at a minimum.

Thus there is no mystery about the nearly universal occurrence of sexuality in organisms. Sexual reproduction is widespread because it has promoted the survival of the species having it. In this way, it is like any other adaptation that increases a species' chances for survival.

Several of the articles in this issue mention *fertilization,* the fusion of the sex cells from a male and a female organism. You should remind your pupils that fertilization must be preceded by cell division (called *meiosis*), which halves the number of chromosomes in the sex cells. Later, when the male and female sex cells fuse and each contributes its chromosomes, the fertilized egg has the normal number of chromosomes for that species of plant or animal.

How Plants Reproduce

Asexual reproduction is common in plants; in fact, many plants have special organs for this sort of reproduction. Examples include the tubers of potatoes, bulbs of onions or tulips, and

(Continued on the next page)

science
SPECIAL TOPIC ISSUE
HOW PLANTS AND ANIMALS
REPRODUCE
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REPRODUCE
Can you roll your tongue like this? It depends on the "blueprint" your parents passed on to you. — See page 13

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 1T-4T.)

Squeals, Squawks, Trills, and Croaks
The unusual calls of frogs and toads play a vital role in the reproduction of these animals.

● **How Plants Reproduce**
Your pupils can learn about reproduction in ferns and flowering plants by experimenting with pollen and spores.

From "Blobs" to Lions
Sexual reproduction insures the survival of a species, and allows it to evolve as its environment changes.

● **Six Ways to Success**
This WALL CHART shows examples of the six main ways in which reproduction can be modified to insure survival of a species.

● **Blueprints Inside of You**
An introduction to the study of genetics, from the work of Mendel to the DNA molecule.

● **The Guppy's Secret Life**
This SCIENCE WORKSHOP tells how to keep guppies and observe their courtship, mating, and birth.

IN THE NEXT ISSUE

SCIENCE WORKSHOPS: First of three articles on earthworm ecology, behavior, anatomy; measuring the air you breathe; when to plant in the spring . . . An anthropologist studies the ways of a pygmy band by living with them . . . Energy—is it potential or kinetic?

Using This Issue . . .

(continued from page 1T)

runners of strawberries. For more information about producing plants in this way, see the article "Growing Plants Without Seeds" (N&S, *Dec. 19, 1966*).

Flowering plants are the most successful group of land plants. This is due mostly to: 1) the evolution of a great variety of ways for getting pollen (the equivalent of an animal's sperm cells) from one individual to the egg cells of others, and 2) the evolution of the seed, which provides food and protection for the embryo plant.

Topics for Class Discussion

The diagram with the article in the student's edition shows how nuclei from the pollen tube fuse with nuclei in the ovary, forming an embryo plant and food called *endosperm*. Your pupils may wonder what happens next.

The ovule enlarges as the embryo and endosperm grow, and it develops a tough, protective coat. The ovule containing the embryo and endosperm is called a *seed*. Endosperm tissue makes up the bulk of grain seeds such as wheat, oats, and rye.

As the tissues of the ovule develop into a seed, the ovary tissues grow into a *fruit*. The fruit may be fleshy and edible; besides the foods (such as peaches and apricots) that we call "fruits," beans, corn, tomatoes, and cucumbers are also fruits in the botanical sense of the word. In many plants, fruits develop into forms such as "wings" or barbs that aid in dispersal of the seeds.

- Some of your pupils may point out that pollen from a flower may pollinate the ovules of the same flower, without being carried by an insect or the wind. This is called *self-pollination*. The plants that result from such reproduction are usually less healthy than those produced by *cross-pollination*—when the pollen from one flower pollinates the flower of another plant of the same species. In some kinds of plants, the male and female parts develop on separate plants, insuring cross-pollination. Many kinds of plants develop in such a way that the pollen of one flower cannot reach the stigma of the same flower. The Dutchman's pipe shown in the WALL CHART is an example.

References

- For more information and activities on flowering plants, see these articles and the accompanying Teacher's Edition: "What Is a Flower?" and "How Pollen Gets Around," N&S, May 17, 1965; "How Seeds Get Around," N&S, Nov. 2, 1964. These articles are also available in Resource Study Unit No. 103, "Investigations With Plants."

Six Ways to Success

This WALL CHART illustrates the main ways in which life has evolved, through natural selection, to insure successful reproduction. You might divide your class into six groups, assign one mode of reproduction success to each group, and then have them investigate and report on other plants or animals that "use" that mode.

Be sure to ask your class how the human species insures reproductive success. Like it or not, they will have to admit that the chief characteristic is *parental care*, probably the longest of all animals.

Blueprints Inside of You

The subject of genetics can be approached in many different ways, but none seems better than beginning at the beginning, with Gregor Mendel's work. His success in investigating how characteristics are inherited can be credited to great wisdom, luck, or both. Before Mendel, scientists had studied the whole inheritance of individuals; Mendel focused his attention on isolated, single characteristics (traits) *(see diagram)*. The sweet peas he worked with differed in clear-cut ways. Mendel was probably aware of this advantage; he was attempting to investigate the simplest kind of heredity. He also kept accurate and complete records and cross-bred great numbers of plants, amassing a lot of evidence on which to base his conclusions.

(continued on page 3T)

THE SEVEN TRAITS OF GARDEN PEAS STUDIED BY MENDEL

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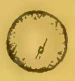
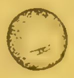
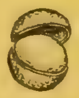
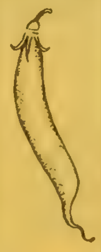
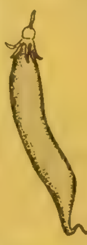
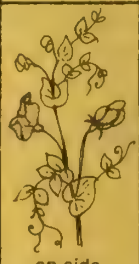
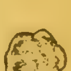
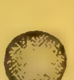
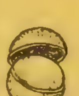
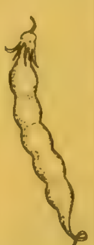
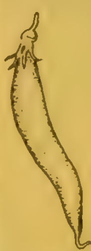
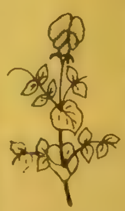
DOMINANT	 round	 yellow	 colored	 inflated	 green	 on side "stems"	lor
RECESSIVE	 wrinkled	 green	 white	 constricted	 yellow	 on tip of stem	sh

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VOL. 4 NO. 13 / MARCH 27, 1967

SPECIAL-TOPIC ISSUE

HOW PLANTS AND ANIMALS
REPRODUCE
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Can you roll your tongue like this? It depends on the "blueprint" your parents passed on to you. — See page 13

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ABOUT THIS ISSUE

HOW PLANTS AND ANIMALS
REPRODUCE
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■ The cycle of life in any living thing begins with rep duction. A new individual plant or animal then devel into an adult and is ready to produce offspring of its o So the cycle of life goes.

Each stage in the cycle is important, but since reproc tion begins the cycle of life for new plants and anim it is the link between generations. Without success in production, a species of plant or animal would die *(see "From 'Blobs' to Lions," and "Six Ways to Succe in this issue).*

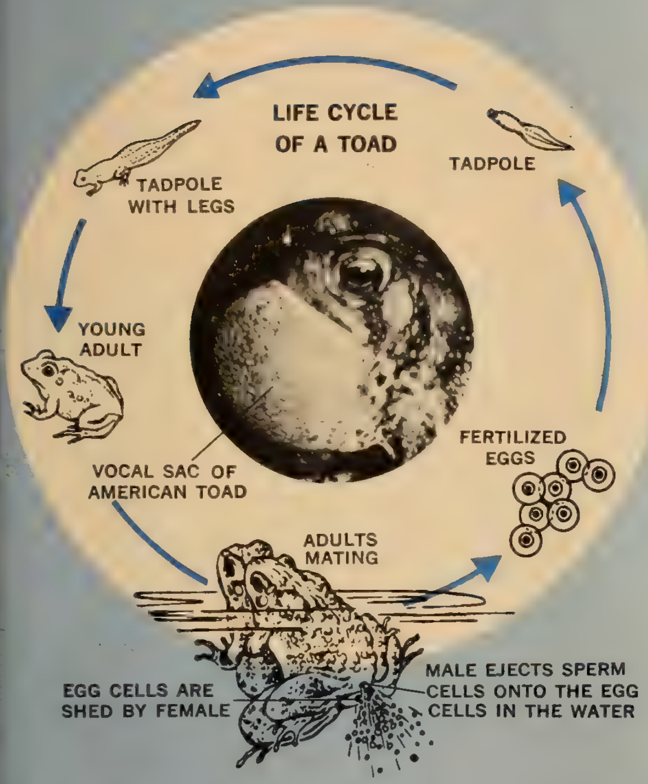
In some kinds of organisms, only one parent is nee for reproduction. You can get new plants of some ki for example, by simply putting a leaf or stem partwa the soil and giving it proper care *(see "Growing Pl Without Seeds,"* N&S, *December 19, 1966).*

For most of the organisms on earth, however, parents—a male and a female—are needed for reproc tion. Each parent produces a sex cell, or *gamete.* W the female gamete, or *egg,* joins with the male gam the egg is said to be *fertilized.* The fertilized egg then be to develop into a new individual animal or plant.

This is the basic plan for *sexual* reproduction. Mos the species of plants and animals on earth follow this p although there are many different ways of getting gametes together. Articles in this issue describe how g pies, plants, and frogs reproduce. And the article, "B prints Inside of You," tells what biologists have discove about the chemical "set of directions" inside each tilized egg; these directions, inherited in part from e parent, determine what the fertilized egg is to become.

This special-topic issue was prepared with the ad of Dr. Donn E. Rosen, who is Chairman of the Dep ment of Ichthyology of The American Museum of Nat History. Editor of the issue for *Nature and Science* Laurence P. Pringle ■

SQUEALS, SQUAWKS, TRILLS & CROAKS


LIFE CYCLE OF A TOAD
TADPOLE
TADPOLE WITH LEGS
YOUNG ADULT
FERTILIZED EGGS
VOCAL SAC OF AMERICAN TOAD
ADULTS MATING
EGG CELLS ARE SHED BY FEMALE
MALE EJECTS SPERM CELLS ONTO THE EGG CELLS IN THE WATER

■ These are the calls of frogs and toads—a much surer sign of spring than the first robin. Why are they calling? Surprisingly, no one bothered to find out until early in this century. Then biologists discovered that, with a few exceptions, only the male frogs and toads make these sounds. Their calls attract the females, and the animals then mate (although a few species manage to find mates without uttering sounds at all).

Since then, as biologists have learned more about how frogs and toads reproduce *(see diagram, "Life Cycle of a Toad")*, they have also uncovered many puzzling questions. How do the animals make their calls? Do the females locate the males by sound alone? What triggers the migration of these animals to their breeding pools each spring?

In trying to answer questions like these, biologists often have to prowl about at night, when the frogs and toads are most active. Some animals are collected and cut open *(dissected)*, to find out more about how the calls are made and about the production of sex cells in the animals' bodies. The biologists also make recordings of the animals' calls.

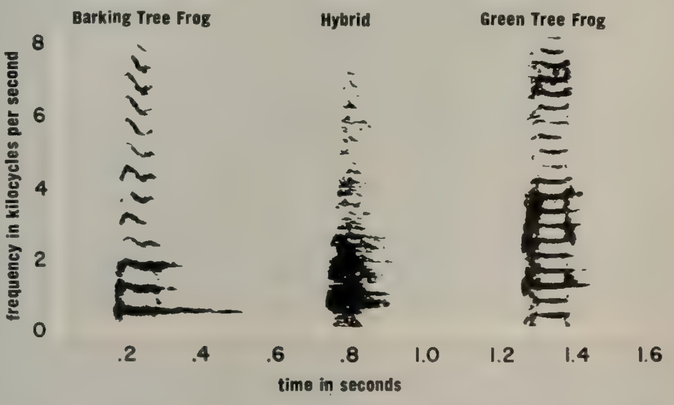
From studies like these, some of the questions about the lives of frogs and toads have been answered. Take, for example, the calls themselves. It seems that each species of frog and toad has a distinctive call. Some tree frogs have a short call like a dog's bark. One common American toad (the Great Plains toad) has a trill that may last a minute. Calls are made in several different ways, but in many frogs and toads, a loose pouch of skin on the throat, called a *vocal sac,* helps produce the sound.

To make its call, the Great Plains toad apparently takes in an extra supply of air, filling its vocal sac so that it puffs out *(see photo)*. Then small amounts of air are "pushed" back and forth between the animal's lungs and its vocal sac. As the air rushes back and forth, it passes over the vocal cords in the throat, making them vibrate. This produces the toad's trilling sounds.

To get a good idea of the variety of calls made by frogs and toads, visit some ponds in Florida on a summer night. You may find as many as 14 different species of frogs gathered in one pond, each giving its distinctive call. You'll probably have trouble telling some of the calls apart. But the female frogs seem to be able to distinguish between all these calls and find their way to the males of their species. Whether they do it by hearing alone is still not known.

By making recordings of frog and toad calls, biologists are able to study them more easily, especially when the call is recorded in the form of a *spectrogram (see below).* These "written records" of a frog's call sometimes reveal differences in calls that cannot be detected by human ears.

Spectrograms are important in *systematics*–the study of how groups of animals are related to each other, and in *taxonomy*–the study of how animals should be classified and named. A biologist may wonder if a toad in one state is the same species as a similar-looking toad in another part of the country. By comparing spectrograms of their calls, he may find the answer.—LAURENCE P. PRINGLE



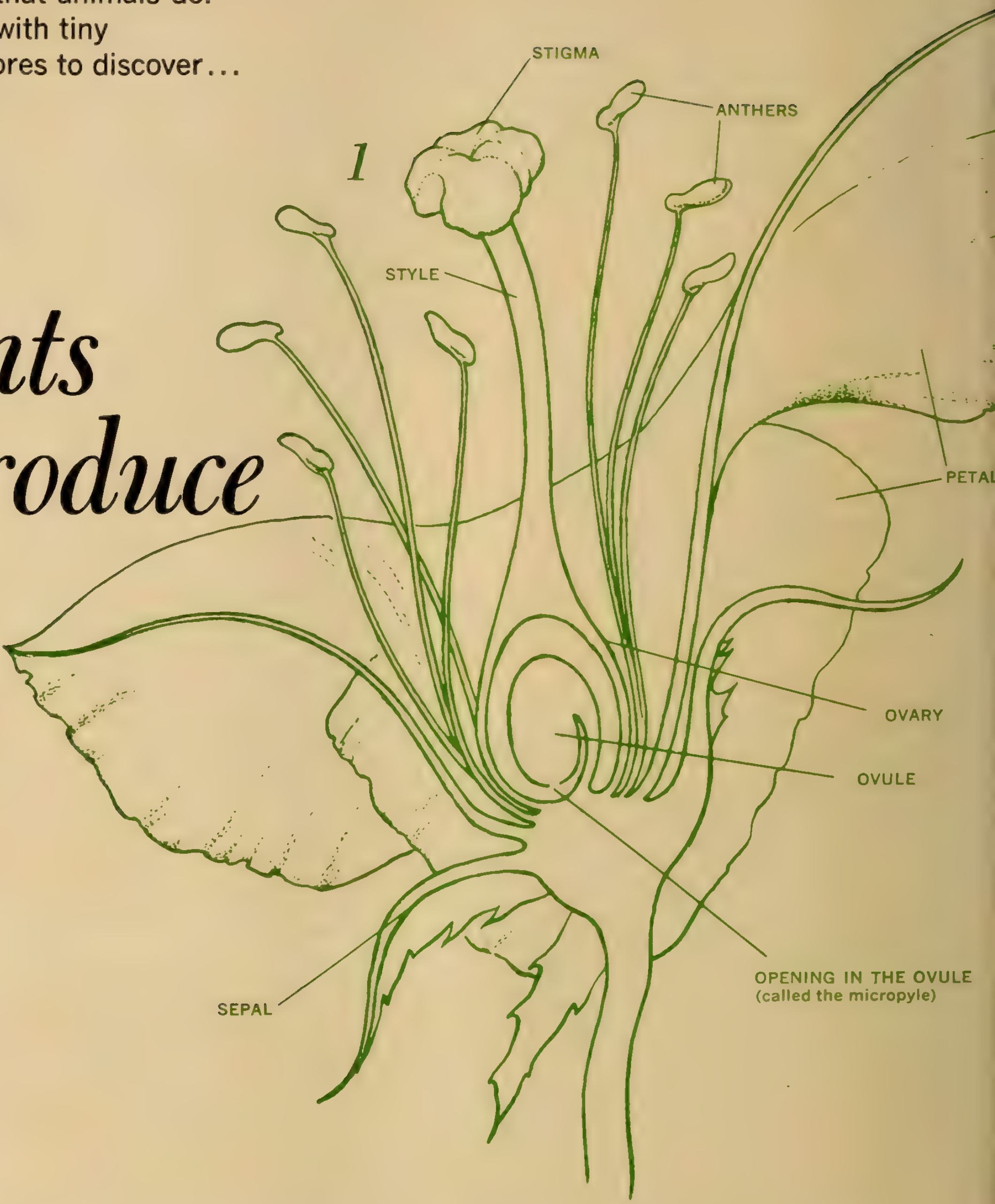
These spectrograms show the pitch (frequency of vibration) and the length in seconds of three different frog calls. The middle call is from a *hybrid*—a frog produced when frogs of the other two species mated. The hybrid was discovered when a biologist heard its distinctive call.

Many plants produce young in
the same basic way that animals do.
You can experiment with tiny
pollen grains and spores to discover...

How Plants Reproduce

by
Richard M. Klein

1



■ How is a toad like a tulip? What do crows and crocuses have in common? Strange as it may seem, tulips and crocuses produce new plants in the same basic way that toads, crows, and other animals produce young—by uniting a male sex cell with a female sex cell.

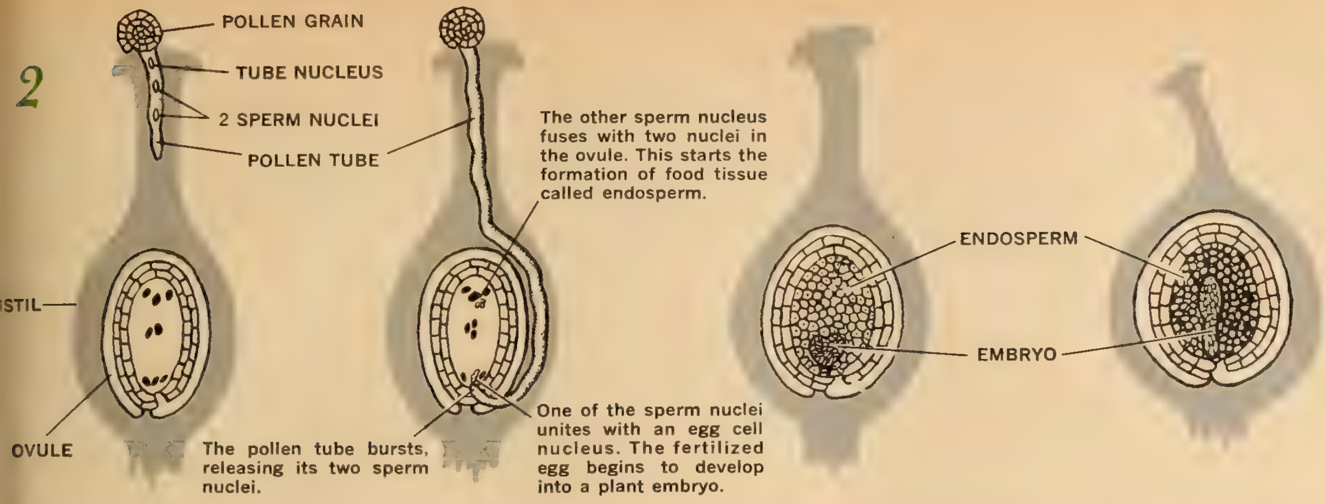
Of course, the ways in which the sex cells, or *gametes,* reach each other are very different in plants than they are in animals. It took plant scientists a long time to figure out the process, and there are still many details to be worked out.

The male gametes of flowering plants are inside grains of *pollen*—the fine yellow dust that you see on the *anthers* of many flowers *(see Diagram 1).* Pollen is carried from one plant to another by insects, hummingbirds, and ever by bats. The pollen from some kinds of flowering plant is spread by water or the wind.

No matter how they are spread, some pollen grain eventually land on the top of the female part of a flowe of the same kind the pollen came from. Diagram 2 show what happens then. The investigations on the next pag tell how you can experiment with the growth of polle grains.

Dr. Richard M. Klein is Caspary Curator of Plant Physiology a the New York Botanical Garden.

2



The pollen tube bursts, releasing its two sperm nuclei.

The other sperm nucleus fuses with two nuclei in the ovule. This starts the formation of food tissue called endosperm.

One of the sperm nuclei unites with an egg cell nucleus. The fertilized egg begins to develop into a plant embryo.

INVESTIGATIONS

How Does A Pollen Tube Grow?

- To get a close look at the pollen tubes that carry male gametes to the egg cells of flowering plants, first dissolve a tablespoon of sugar in a cup of water. Measure out two ounces of this solution. Then add to it a drop of concentrated boric acid solution (available from a drugstore). The boric acid helps speed the growth of pollen tubes.

Next, collect some pollen from the anthers of plants such as lilies, narcissus, and other spring flowers. Put a drop or two of the sugar-boric acid solution on a piece of wax paper or on a microscope slide. Then dust a little of the pollen onto the water drop. Look at the water with a magnifying glass or a flashlight magnifier that enlarges objects at least five times. Use a low-power microscope if you have one or can borrow one.

The pollen tubes should start growing within a few minutes after you put the pollen grains in the water. How long do they get? By putting pollen grains from several different kinds of flowers in drops of the sugar solution, you can compare the speed of growth of the pollen tubes.

- Many different substances will affect the growth of pollen tubes. You might test the effects of epsom salts, sodium bicarbonate, table salt, and vinegar by adding a bit of each substance to a different container of your basic sugar solution. Then put pollen grains in drops of the different solutions to see how they are affected. Write a label near each drop so you can tell which substance you are testing.

- When a pollen grain lands on the top of the pistil (called the *stigma*) of a plant of the same kind, it begins to form a pollen tube. But what happens when a pollen grain from a *different* kind of flower lands on the same stigma? Do these "foreign" pollen grains also form pollen tubes? You can find out by chopping up the stigmas of flowers such as Easter lilies or tulips. Put the chopped bits of stigma into two separate drops of your sugar-boric acid solution. Then add pollen grains from the same kind of plant to one drop, and pollen from a different kind of plant to the second drop. Do all of the pollen grains form tubes? How would you explain your results?

Look on the underside of fern leaves for sori like these. Spores are produced inside the sori.

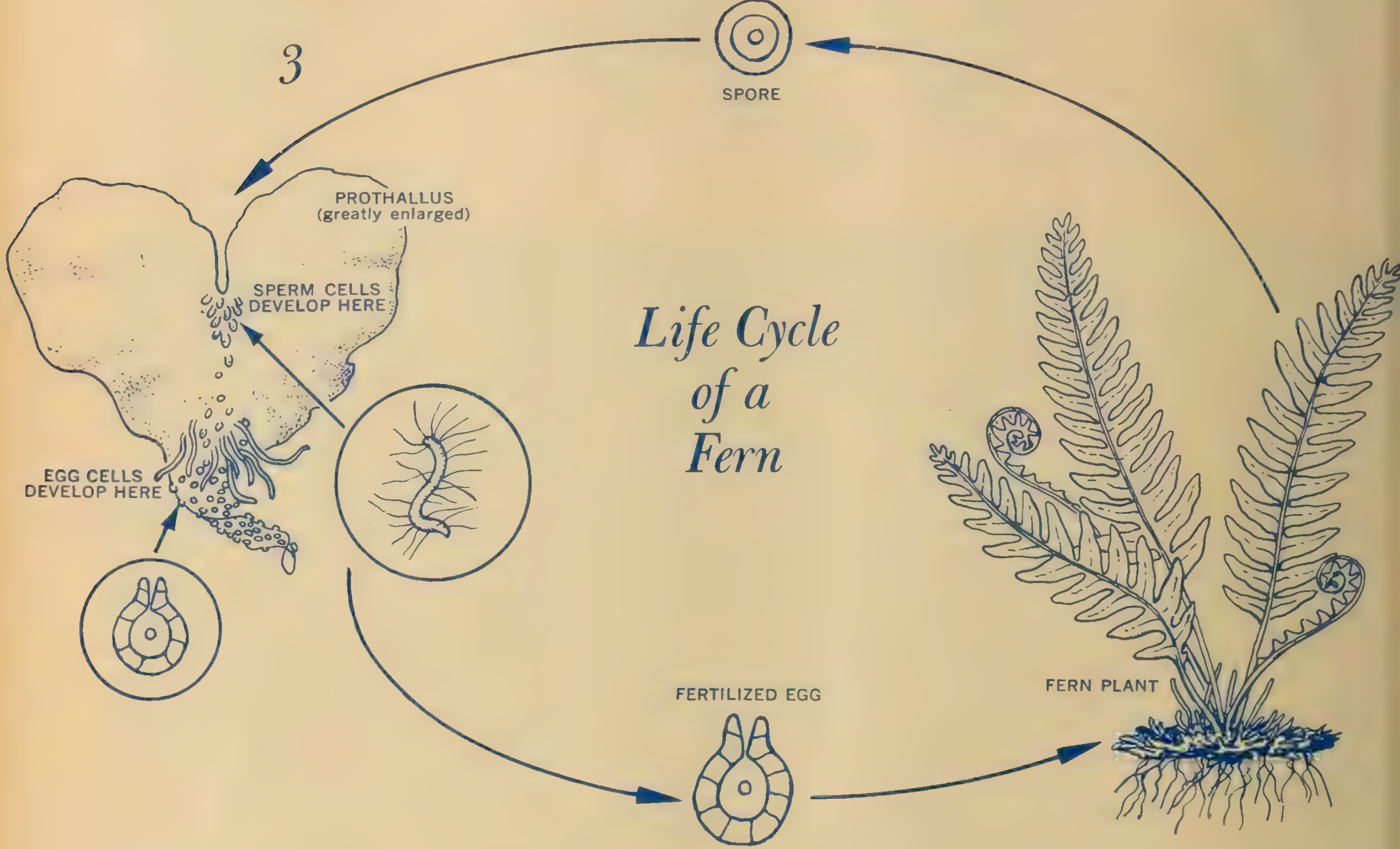
From Spore to Fern

Not all plants reproduce by way of flowers. Some algae and many of the *fungi* (including molds) have complicated life cycles of three or more stages. Many ferns produce new plants in a two-stage cycle *(see Diagram 3 on next page)*. If you look at the underside of a fern leaf, you will find small brownish spots *(see photo)*. These raised bumps are called *sori*, and they contain spores. The spores are about the size of pollen grains, but they "work" in a different way.

(Continued on the next page)

When a fern spore lands on some damp earth or another favorable spot, it grows into a thin, heart-shaped body, called a *prothallus*. As the prothallus grows, it produces sex cells—sperms and eggs. Each egg is fertilized by a sperm cell *(see Diagram 3)*, and then the fertilized egg begins to grow into a fern plant ■

■ For more information about plants and plant reproduction, look for these books in your library or bookstore: **The Secret Life of the Flowers,** by Anne Ophelia Dowden, Odyssey Press, New York, 1964, 95 cents; **The Plants,** by Frits Went, LIFE Nature Library, Time, Inc., New York, 1963, $3.95; **Introduction to Botany,** by H. J. M. Bowen, Arco Publishing Co., New York, 1965, $1.65 (paper).



PROJECT

You can grow your own fern plants from tiny spores. First, get a fern plant from a florist's shop. If it isn't convenient for you to do this, try this project a few months from now when you can find ferns growing in a nearby woods. Once you have a fern leaf with sori on it, get a small clay pot (the inside of the top of the pot should be one or two inches wide). Wash the pot thoroughly, and soak it in water for several hours, changing the water several times. This removes minerals in the clay that might poison the fern spores.

Next place the pot upside down on a saucer. Collect some of the powdery fern spores on a piece of white paper by breaking open a few sori with a needle. Sprinkle the spores on the surface of the pot. Then cover the pot with a glass jar and put it in a dimly-lit place at room temperature. Add a little water to the saucer whenever the surface of the pot begins to dry out.

If the spores form a prothallus, you will be able to see it in about two weeks. Look carefully—at this stage it will only be a small green spot. In another two weeks, the prothallus will be about a half inch in diameter and will look heart-shaped *(see Diagram 3)*. In another two or three weeks you will see the prothallus die and shrivel up, but a small fern plant will be growing in its place. You can then transplant the fern to a pot of light, rich soil.

FROM "BLOBS" TO LIONS

■ Picture a male lion in Africa. He is the strongest and most cunning of all the lions for miles around. He lives a long life—much longer than most lions.

"Aha," someone may say, "This is a clear case of 'survival of the fittest.' A plant or animal that can protect itself and get the most food usually lives longer than those of its kind that are less able."

But "survival of the fittest" means more than just the ability of a *single* plant or animal to keep alive. A biologist uses these words to describe the ability of the *species* (kind) of plant or animal to survive, instead of dying out as so many species of plants and animals have done since the earth was formed. For a species to survive, individual plants or animals of that species must do more than just live; they must live *long enough* to reproduce more of their kind, *and* they must *be able* to reproduce more of their kind.

If that male lion cannot mate with a female and have some offspring, his own long life adds nothing to the survival of the lion species. But if he does mate and have offspring, he not only adds new lions to the species; he also passes on to them some of the characteristics that helped him live so long.

No Two Alike

Each new plant or animal that is reproduced inherits a chemical "set of directions" from its parents (*see "Blueprints Inside of You," in this issue*). No set of directions is exactly like another. This is why no two plants or animals are exactly alike. Biologists call this great variety among individual plants and animals *genetic variability.*

Even among the earliest "blob-like," simple plants and animals on earth, the individual plants and animals were different from each other. When these individuals mated, each of their offspring inherited characteristics that made them different from their parents *and* from the other young. In this way, as generations followed generations over millions of years, plants and animals became different from their simple ancestors.

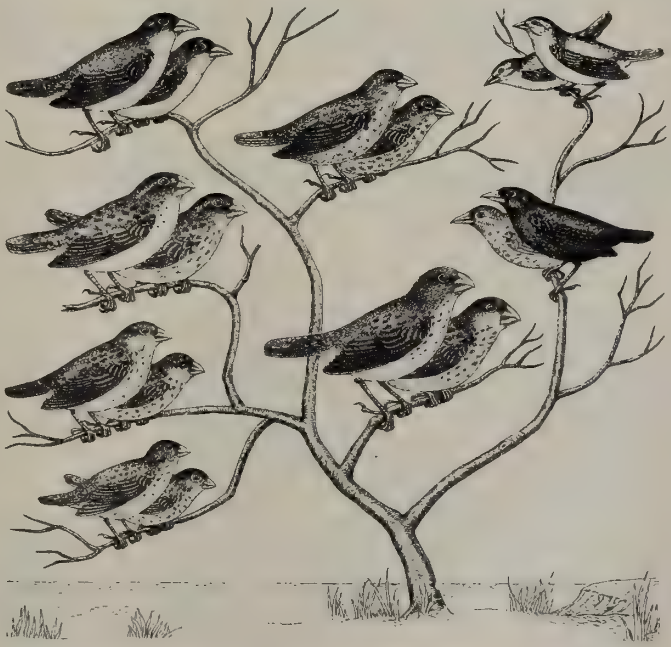
The variations among the individual members of a species are very important for the survival of the species. They give a species of plant or animal a "reserve fund" of different characteristics to draw on if conditions change. Suppose, for example, that a species of mouse is faced with a change of climate in the land where it lives. The climate grows steadily colder. If all of the mice were exactly alike, the species might eventually be wiped out.

But because of genetic variability, the mice are not all alike. Some may have longer fur or some other characteristic that enables them to withstand the cold better than others. These individuals are more likely to live long enough to reproduce and pass their characteristics on to the next generation.

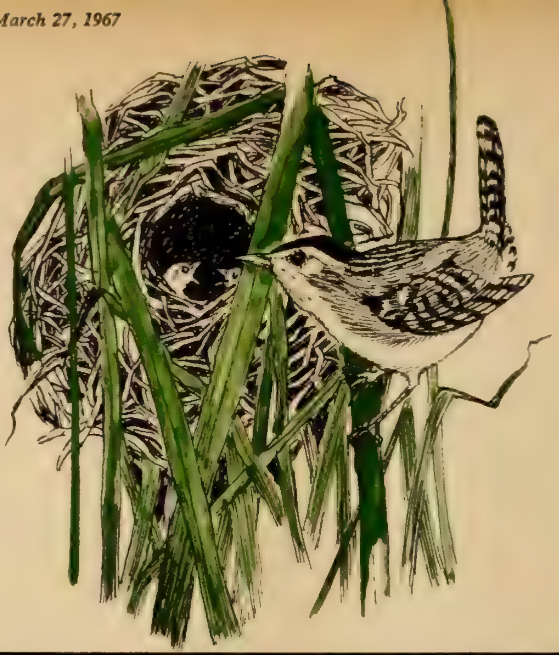
If a species moves into a new area, variability enables it to *evolve,* or slowly change, in different ways to adapt to the different conditions there (*see "The Case of the Pale Sparrows,"* N&S, *December 5, 1966*). The drawing on this page shows how this worked when a single species of bird reached some islands off the coast of South America.

Even when there are no drastic changes in living conditions, species of plants and animals keep evolving in an important way — bettering their ways of reproduction. The WALL CHART on the next page shows six ways that help animals and plants to reproduce successfully.

—MARGARET BULLITT



Thousands of years ago, some individuals of a single kind of finch reached the Galapagos Islands from South America. If there had been no variation in these original finches, today only this species would be found on the islands. This drawing shows some of 14 different species of finches that have evolved on the Galapagos Islands.



1 *Reproducing Often*

Small birds such as wrens breed when they are a year old. If they successfully raise young early in the season they often nest again. Wrens may raise three broods in a year. If their nests are destroyed, many small birds will build another nest and lay more eggs as many times as needed to successfully raise young.

2 *Maturing at Different Ages*

Eagles, which live for 20 or more years, do not breed until they are four or five years old. When they breed, each pair of eagles has a specific area or *territory* where it hunts. They chase other eagles out of their territory, because if there are too many eagles in one territory there will not be enough food to go around. If an eagle were to breed at a younger age it might not be strong enough to defend its territory and to successfully raise its young. Other kinds of animals, with much shorter life spans, develop into mature adults sooner and breed at an earlier age.

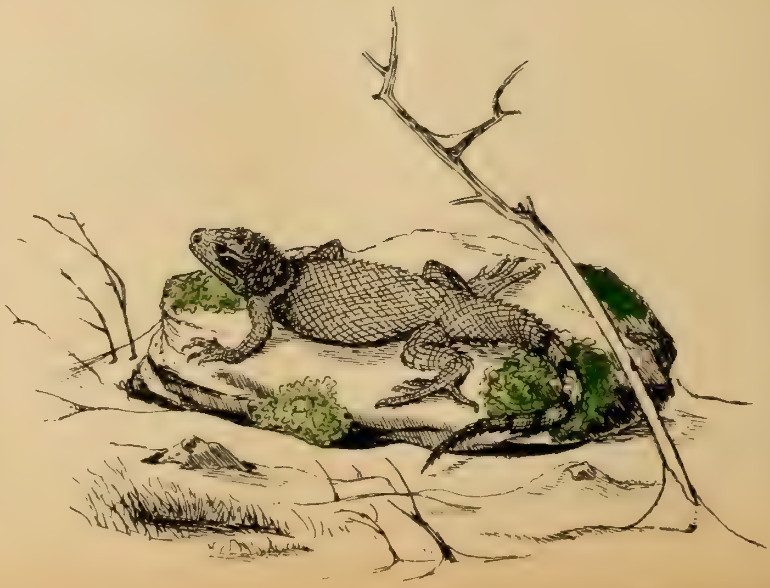
Six Ways to Success

For a species of plant or animal to survi
it must produce young, and some of
young must also live long enough to ha
offspring. If it fails to do this, the spec
soon dies out.

No wonder, then, that different kinds
plants and animals have such a variety
ways for producing young successfu
The illustrations on these pages show
amples of the six main ways in which pla
and animals are adapted to produce a n
generation.—MARGARET BULLITT

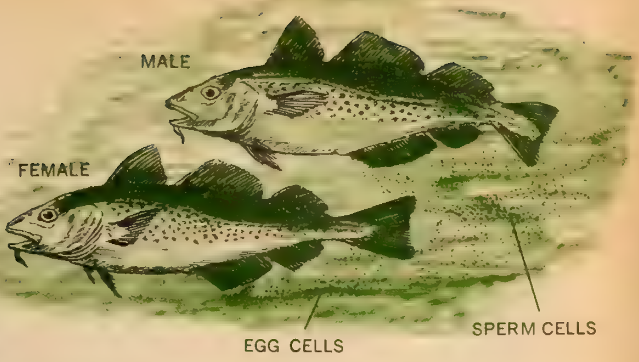
5 *Protecting The Fertilized Eggs*

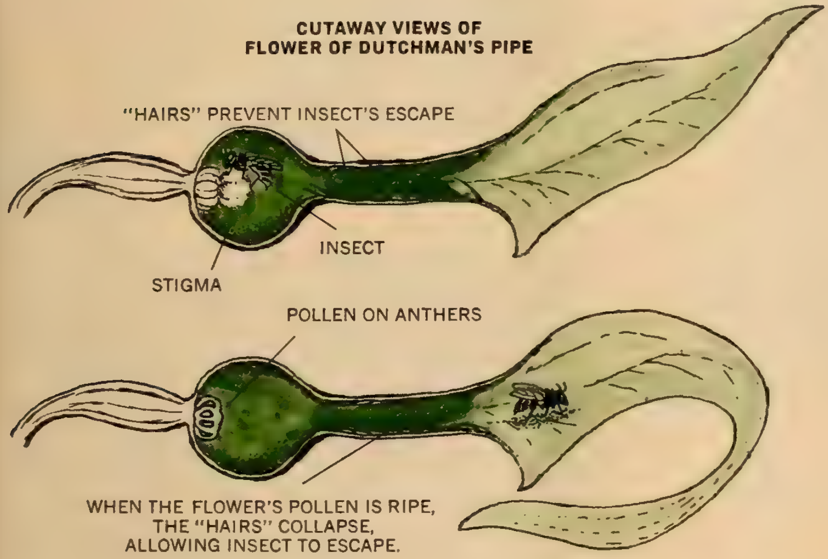
Most female lizards lay eggs, burying them in moist, warm places where they hatch. However, some kinds of lizards that live in cold areas on mountain tops or in northern areas, do not lay their eggs. The climate is too cool for the fertilized eggs to develop. The lizards keep the eggs inside their bodies until they are almost ready to hatch. In some kinds of lizards, the eggs actually hatch inside the body. The female lizards with the eggs inside their bodies can bask in the sun and move to spots where the temperature is warm enough for the development of the eggs.



3 *Many Sex Cells*

When cod mate, or *spawn*, a female fish may release as many as four to six million egg cells in the water. At the same time the male releases millions of sperm cells *(see diagram)* that unite with many of the eggs. Even though cod do not protect their eggs or young and many of them are eaten by other fish, the great numbers of fertilized eggs insure that some will survive to become adults.


MALE
FEMALE
EGG CELLS
SPERM CELLS


CUTAWAY VIEWS OF
FLOWER OF DUTCHMAN'S PIPE
"HAIRS" PREVENT INSECT'S ESCAPE
INSECT
STIGMA
POLLEN ON ANTHERS
WHEN THE FLOWER'S POLLEN IS RIPE,
THE "HAIRS" COLLAPSE,
ALLOWING INSECT TO ESCAPE.

4 *Getting Gametes Together*

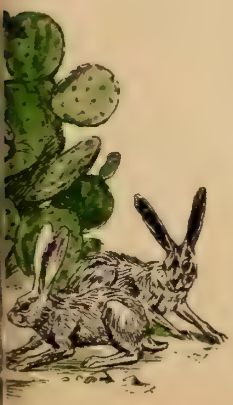
When an insect flies from one flower to another of the same kind, it accidentally brings the plant's *gametes* (sex cells) together. Many kinds of plants have flowers with shapes, smells, and colors that attract certain insects. This helps insure fertilization of their egg cells *(see "How Plants Reproduce," in this issue)*.

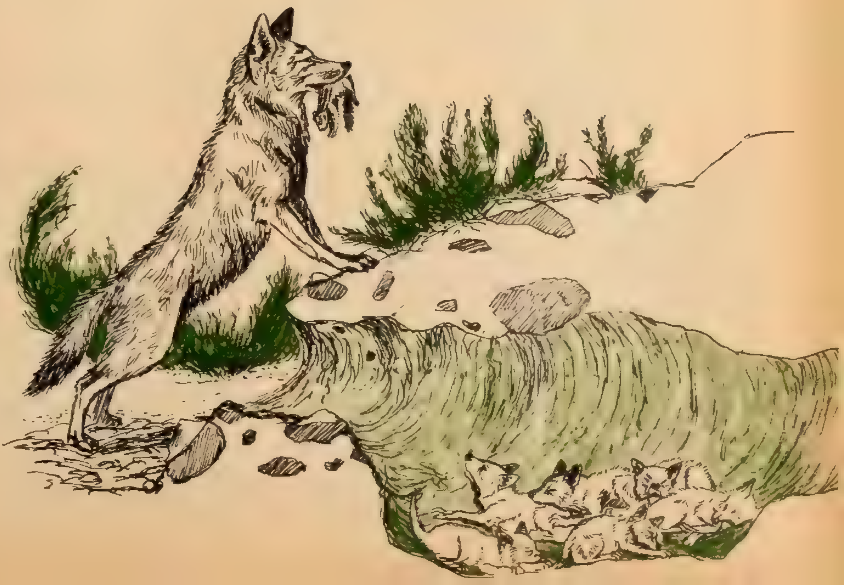
In the flowers of Dutchman's pipe *(see diagram)*, the female gametes ripen before the male gametes (in pollen grains) do. An insect must crawl to the bottom of a flower to get the nectar it uses for food. In doing so, it touches the sticky stigma, which picks up any pollen that the insect is carrying. This pollen will fertilize the egg cells of the flower. But the stiff "hairs" *(see diagram)* trap the insect inside the flower until the pollen of the flower is ripe. Then the "hairs" collapse. As the insect crawls out, some pollen sticks to its body. The insect then carries the pollen to the next flower of Dutchman's pipe that it visits.

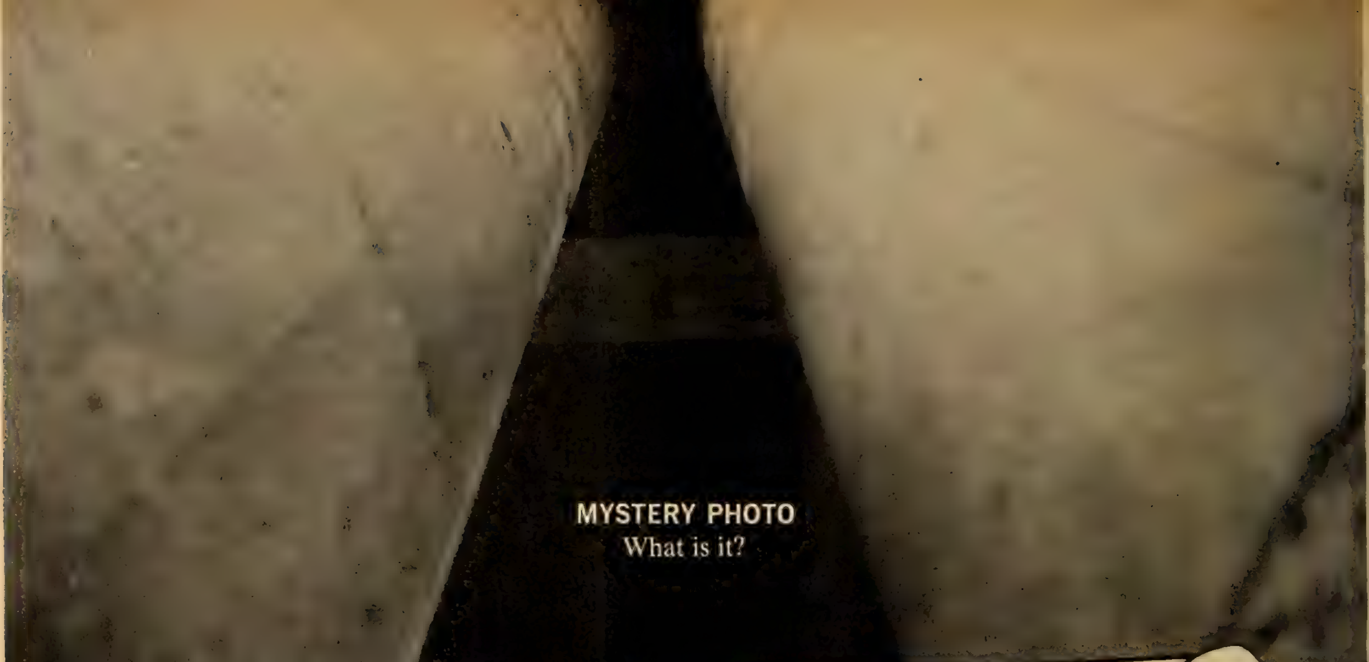
6 *Surviving After Birth*

Jack rabbits are able to see, hear, and run soon after they are born. If necessary, they can survive without their mother a few days after birth. Since many animals catch and eat jack rabbits, it is important that the young can survive if their mother is killed.

Young coyotes are quite helpless when born. They do not begin to see or hear well until they are two or three weeks old. The pups depend on their mother for food and care, and learn to catch their food by imitating her. Without parental care, the pups could not survive.







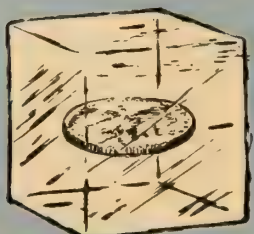
MYSTERY PHOTO
What is it?

BRAIN-BOOSTERS

prepared by
DAVID WEBSTER

CAN YOU DO IT?

Can you make an ice cube with a penny inside?

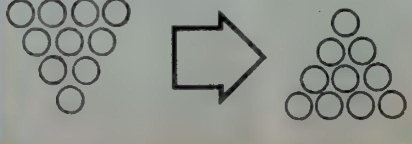


What will happen if

. . . you stand on a bathroom scale with one leg in the air? Will it still show your whole weight?

FUN WITH NUMBERS AND SHAPES

Place 10 pennies like this: Can you reverse the pattern by moving only 3 pennies?



FOR SCIENCE EXPERTS ONLY

How can an earth-bound creature experience the most daylight hours in a year with the least travel?

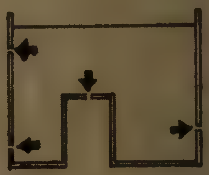
Submitted by Mrs. S. L. Finch, Portland, Indiana

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: A piece of screen floats because of *surface tension,* the force that makes the surface of water act as if it were covered with an elastic skin. This force is not strong enough to prevent a stream of water from running through the screen.

Can you do it? It is not possible to fold a piece of paper in half nine times, regardless of its size or thinness.

What would happen if? Water would squirt out fastest from the lowest hole (Number 1). If this hole were closed, would water then come out of the other holes faster?



Fun with numbers and shapes: One orange 3 inches in diameter is larger than three oranges that are 2 inches in diameter. How many 1-inch oranges would you need to equal a 3-inch orange?

For science experts only: Gear G is turning around three times a minute, which is the same speed as Gear A. Two gears with an equal number of teeth will turn at the same speed regardless of the number and size of the gears between them.

As you grew from a single tiny cell to a human being, your developing body followed a set of directions. Scientists are still unraveling the mysteries of these . . .

BLUEPRINTS

INSIDE OF YOU

by Diane Sherman

■ You started as a tiny cell. So does every other living thing. But what made you become *you*—not a radish, a rabbit, or a rhinoceros? Why are you light or dark, tall or short, dimpled, freckled, or button-nosed?

Somewhere in the cell that grew to be you, there was a set of directions, a kind of blueprint. It directed your development as an embryo inside your mother's body. And it is determining how you look as you grow up, and affecting many other things about you, too.

The science of *genetics* is the study of these "blueprints." How do they get inside a cell? What are they made of? What do they look like? How do they work? These are some of the questions that scientists called *geneticists* have tried to answer.

Like Peas in a Pod

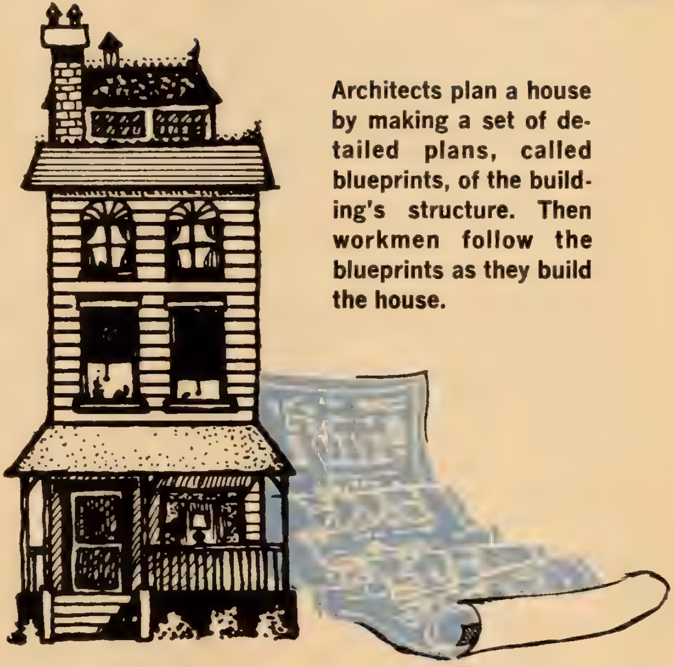
Some of the questions were answered about 100 years ago, when an Austrian monk named Gregor Mendel was experimenting with flowers. He took pollen from one kind of flower and used it to *fertilize* other kinds of flowers *(see "How Plants Reproduce" in this issue)*. This is called *cross-breeding*. When the fertilized flowers produced seeds, Mendel planted them to see what sort of flowers would appear. He discovered that the colors and shapes of the new generation of flowers varied a lot. Just as with children, some of the flowers looked like one "parent," some like the other. Some looked like a combination of the two parents. Still others didn't seem to resemble either parent at all. Mendel began to wonder. Was there any way to predict what a new generation would look like?

Mendel decided to try to find out. He chose different kinds of pea plants to work with. Some were tall, some were short. Some always produced yellow peas, others green. Some always had peas with round seeds. Others always had wrinkled seeds. What would happen, Mendel wondered, if he fertilized the yellow-pea plants with pollen from the green-pea plants? Would the new plants have green peas? Yellow peas? A combination of both? And what would happen if he fertilized the round-pea plants with pollen from the wrinkled-pea plants? To answer these questions, Mendel cross-bred many pea plants.

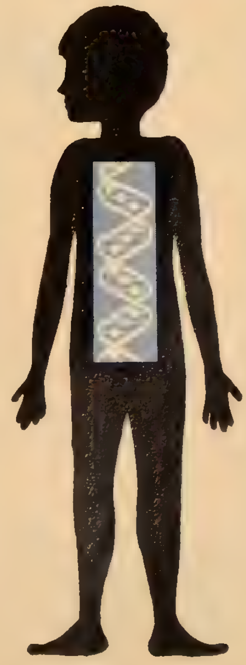
After getting the pea seeds from the parent plants, Mendel put them in soil and waited for new plants to grow. At last they were ready. He discovered that the peas with one green and one yellow parent were all green. The seeds with one round and one wrinkled parent were all round *(see Diagram 1)*. So it went, for each set of characteristics that Mendel had crossed. It seemed that the characteristics, or *traits*, of one parent had "disappeared."

Mendel planted the seeds he got from that experiment and waited to see what would happen to the next genera-

(Continued on the next page)



Architects plan a house by making a set of detailed plans, called blueprints, of the building's structure. Then workmen follow the blueprints as they build the house.



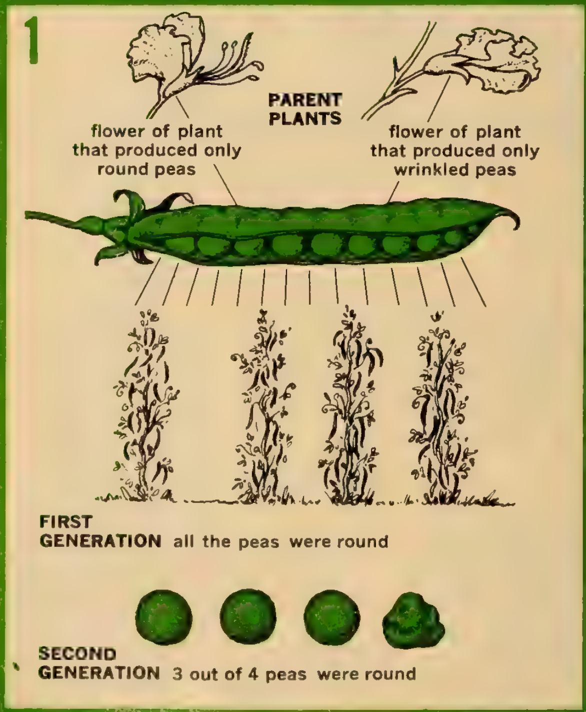
Each cell in your body also contains a blueprint, or set of chemical directions, which your body follows as it develops.

tion. When the pods ripened, yellow peas lay next to green. Wrinkled seeds lay next to round ones. The missing traits had reappeared! Carefully Mendel counted the thousands of different kinds of peas he had planted. He discovered what seemed to be a pattern in the way traits were passed from one generation to the next. For every wrinkled seed, there were about three smooth ones. For every yellow pea, there were about three green ones. In this, the second generation of plants, one out of every four showed the trait that had seemed to be "lost" in the first generation.

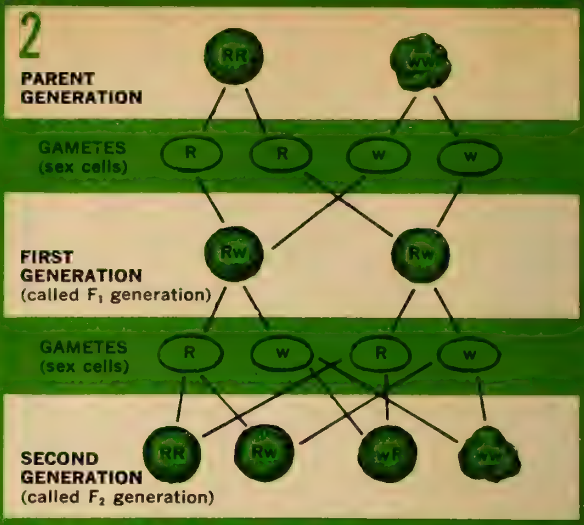
Strong and Weak Traits

Gradually Mendel found a way to explain this pattern. The traits a pea plant inherited from its "parents" depended on two different substances, one from one plant and one from the other. Now suppose one of these substances was stronger than the other. Suppose that every time the two came together, the stronger one *dominated* or "overpowered" the weaker.

To see what would happen, let's call whatever makes seeds round "R," and whatever makes seeds wrinkled "w." We know that each plant in the second generation got a w from one parent and an R from the other *(see Diagram 2)*. If R is stronger than w, that would explain why all the first generation plants had round seeds.


1
PARENT PLANTS
flower of plant that produced only round peas
flower of plant that produced only wrinkled peas
FIRST GENERATION all the peas were round
SECOND GENERATION 3 out of 4 peas were round

This diagram shows what happened when Mendel cross-bred pea plants with wrinkled seeds and pea plants with round seeds. The trait for wrinkled seeds seemed to "disappear" in the first generation, but about one out of every four peas were wrinkled in the second generation.


2
PARENT GENERATION
RR
ww
GAMETES (sex cells)
R
R
w
w
FIRST GENERATION (called F_1 generation)
Rw
Rw
GAMETES (sex cells)
R
w
R
w
SECOND GENERATION (called F_2 generation)
RR
Rw
wR
ww

Mendel was able to explain the results of the experiment shown in Diagram 1 when he discovered that some traits overpower, or "dominate" others, which he called "recessive." Whenever the dominant trait of round peas (R) was combined with the recessive trait of wrinkled peas (w), all the peas were round.

But what about the second generation? Why should one out of four seeds be wrinkled? You remember that in the parent generation, one parent could pass on only an R. The other parent could pass on only a w. But a first generation pea might have either an R *or* a w to pass on to its children *(see Diagram 2)*. Mendel figured out that there were four possible ways for the R's and w's to combine in the second generation. They could join as RR, Rw, wR, and ww. Since R would appear in three out of four combinations, that would explain why three out of every four pea seeds would be round!

Mendel used the word "dominant" to describe the traits like roundness that are always strong enough to appear. The traits that may be hidden for a while he called "recessive." Mendel's discoveries apply to people as well as peas. The combination of dominant and recessive traits that we get from our parents determines our coloring, our size, our features, and many other things about us, too.

Mendel proved that there *is* a pattern to the way living things inherit traits from their parents. He couldn't predict *which* seeds would be round, but he could be pretty sure that if he grew enough of the right kind of pea plants, he would get three round seeds to each wrinkled one.

Some Answers From "The Fly Squad"

For a long time, no one knew what it is in seeds and animals that determines what the next generation will be like. Then, in the years after Mendel's death, other men began to investigate cells. They learned that inside the cells of every living thing are tiny, thread-like bodies called *chromosomes (see photo)*. Every new plant or animal that is formed gets half of its chromosomes from the sex cell of its father, and half from the sex cell of its mother.

Mendel had said there must be some way for each parent to pass on a whole set of dominant and recessive traits to its children. It now seemed likely that the chromosomes carried the directions for all to develop in different ways, but there was no proof.

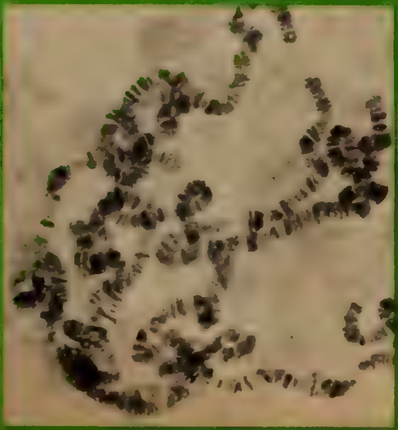
In the early 1900's, a biologist named Dr. Thomas H. Morgan at Columbia University in New York City started thinking about the problem. To find out more about how traits were passed on, he decided to raise many generations of some animal and study the different characteristics that appeared. Morgan worked with *Drosophila,* the tiny fly that buzzes around ripe fruit.

It was a gigantic task that Morgan was undertaking. He had to raise thousands and thousands of flies, and each one had to be examined carefully through a microscope. Soon every inch of his laboratory was covered with milk bottles in which the flies were raised. Other scientists jokingly called Morgan and his assistants "The Fly Squad."

Morgan noticed that some traits in the flies always seemed to go together. Black flies, for instance, always had short wings, while grey flies always had long wings. Why should this be? Could the same chromosome control the fly's wing size *and* its color? Since the cells of fruit flies have only four pairs of chromosomes, it would seem likely that each pair would have to control many characteristics (if they controlled any at all, of course).

As Morgan's work continued, he discovered that the flies seemed to inherit four separate sets of traits. These traits were always inherited as a group. It was as if all green-eyed people had to be freckled, bow-legged, and six feet tall, and as if no one could have one of those characteristics without having them all.

To Morgan, one fact stood out. The flies can inherit only four sets of traits, and they have four pairs of chromosomes. It seemed possible that each pair of chromosomes controlled a set of traits.



is photo, taken
rough a micro-
ope, shows chro-
osomes inside a
ll of *Drosophila,*
e fruit fly.

ABOUT THE COVER

The girl on the cover is "tongue-rolling." The ability to roll your tongue into a U shape is an inherited trait, passed from parent to offspring in chromosomes (see *text*). Find out how many of your family and your classmates are "rollers" and how many are "non-rollers."

Meanwhile, other scientists were studying a different fly that has five pairs of chromosomes. This fly was discovered to have five sets of traits that are always inherited together. Other men studying field corn found 10 sets of traits and 10 pairs of chromosomes. There no longer seemed any doubt. The chromosomes inside the sex cells of plants and animals control the characteristics of the next generation.

Language of the Blueprints

By now scientists were learning more about chromosomes. The chromosomes seemed to be made of small units strung out in a line, and each unit appeared to control some definite characteristic. For example, Dr. Morgan discovered just which part of the fly's chromosomes controls eye color and wing shape.

It was becoming clear that the chromosomes in our body cells are really like a set of master plans, like blueprints that architects and workmen use to construct buildings. The blueprints determine how we grow to be what we are. But in what kind of language are they written?

One way to answer this question was to find out what chromosomes were made of. In 1952 Dr. Alfred Hershey and Dr. Martha Chase discovered it is a chemical substance called *DNA* (which stands for deoxyribose nucleic acid). To find out how DNA works, the next step was to figure out how the chemicals in it are put together.

At a laboratory in Cambridge, England, Dr. Francis Crick and an American named Dr. James Watson decided to try to make a model of a DNA molecule. They knew what some of the particles that made up DNA looked like. The problem was to fit them together correctly.

If they found a solution, it would have to answer a very important question. How does DNA make copies of itself? Every cell in your body has a set of the DNA blueprints exactly like the ones in the cell from which you began. Without the ability to make copies of itself, DNA couldn't pass on information to new generations. It couldn't hand down dominant and recessive traits.

Watson and Crick tried many different models, and threw them away. At last, they thought they had an answer. The DNA molecule, they said, must be like a cir-

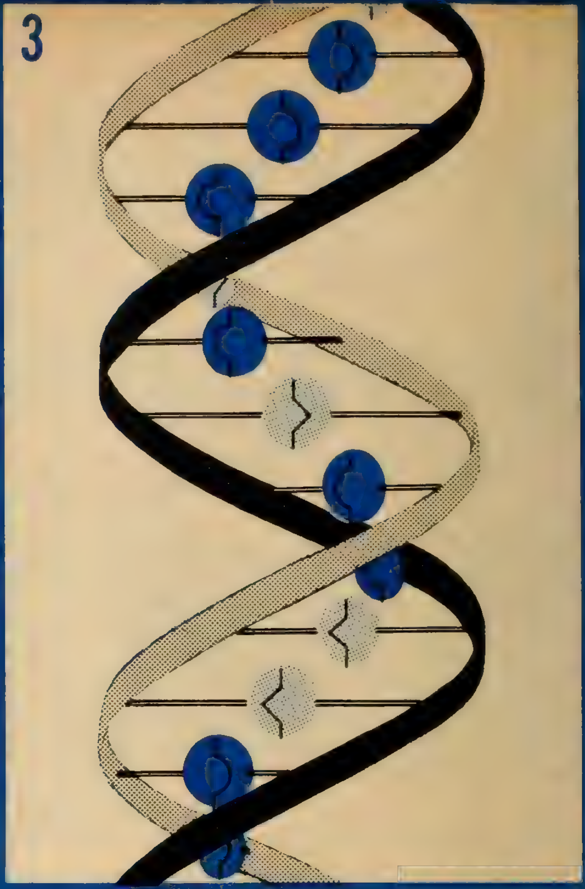
(Continued on the next page)

cular staircase *(see Diagram 3)*. Pictures taken with new kinds of X-ray photography showed that the DNA molecule *did* seem to be shaped like a coil. But how could such a structure make copies of itself?

The scientists suggested that each step of the staircase was made of two separate sections that locked together like pieces of a puzzle. If the staircase split down the middle, the steps would come apart like a zipper being opened. Then each separate half of the staircase could pick up a new half from the chemical pieces in the cell around it. Each step would have to pick up the right kind of piece because that is the only one that would fit. The result would be two coils, exactly alike, where there was only one before. Later experiments showed that this is exactly what happens *(see Diagram 4)*.

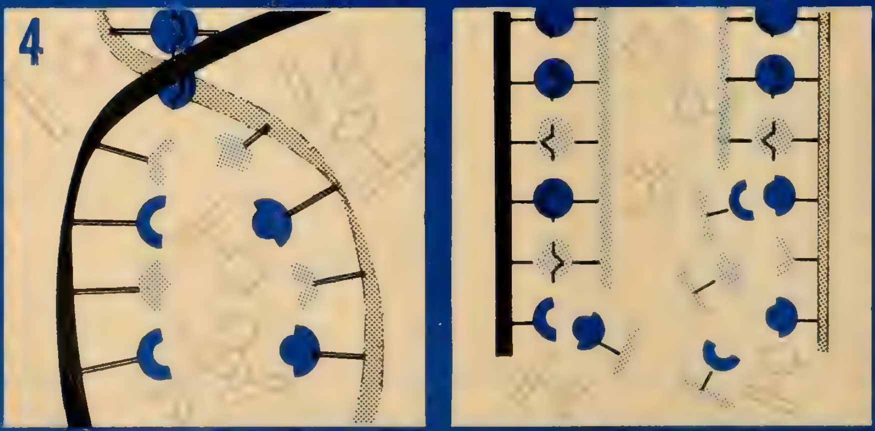
If the Watson and Crick model was right, there were only four different kinds of steps in DNA coils. Could blueprints for all the creatures on earth be produced just by changing the order of these four steps of the DNA staircase? Watson and Crick did some figuring. Each chromosome is made of many strips of DNA. A single strip might have 10,000 steps. In the 46 chromosomes of the human body, there might be six *billion* steps. The scientists figured that there are more than enough different combinations to allow for separate blueprints for every creature that ever lived, and for millions more besides.

There is still much to learn about DNA and how it works. When we know more, perhaps we can change the blueprints to keep people from being born with certain diseases or defects. But that is a long way off. Right now, much of the blueprints are in a code we can't yet decipher. Yet isn't it strange to realize our body cells consult the plans every day, making millions of new body cells for us exactly according to specifications! ■

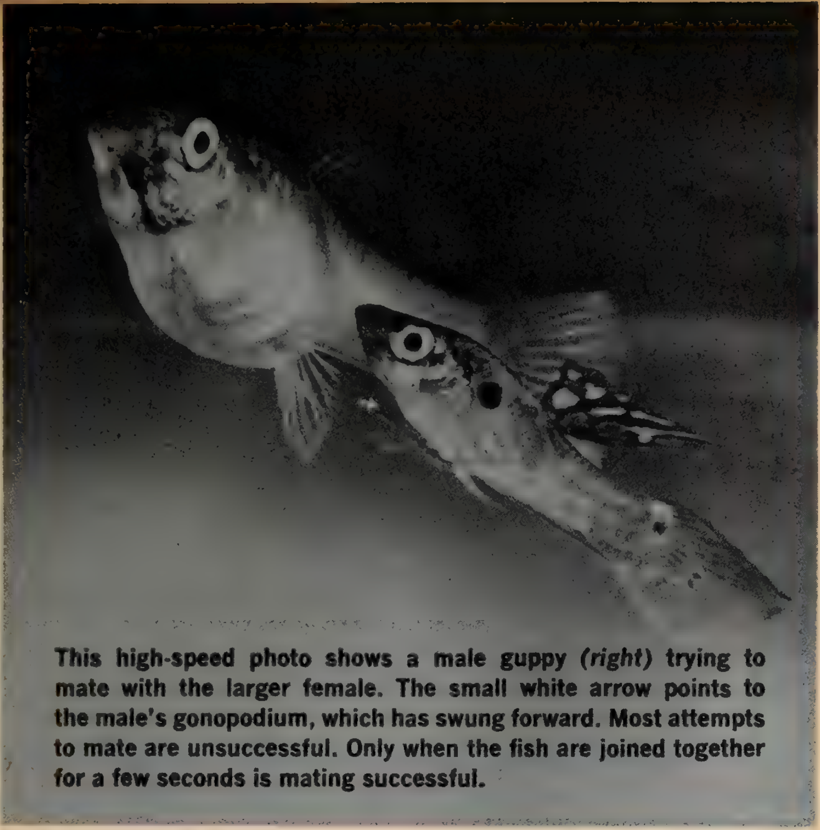


This coiled staircase is a model of a DNA molecule. The "steps" of the staircase are made up of four different kinds of chemicals. The arrangement of the "steps" is like a blueprint for a plant or animal.

■For more information about the study of genetics, look for these books in your library or bookstore: **Who Do You Think You Are? The Story of Heredity,** by M. R. Lerner, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1963, $2.95; **Evolution,** by Irving and Ruth Adler, The John Day Co., New York, 1965, $2.95; **Evolution,** by Ruth Moore, LIFE Nature Library, Time Inc., New York, 1962, $3.95.



Making copies of itself, a DNA molecule splits down the middle *(far left)*. Then the separated halves pick up matching chemical pieces from the surrounding nucleus of the cell *(left)*. Later one of these molecules goes out into the cell where it provides a pattern for the development of the plant or animal.



This high-speed photo shows a male guppy *(right)* trying to mate with the larger female. The small white arrow points to the male's gonopodium, which has swung forward. Most attempts to mate are unsuccessful. Only when the fish are joined together for a few seconds is mating successful.

These small fish have been aquarium pets for many years. Yet their ways of courtship and breeding were discovered just a few years ago. Here is how you can study...

the GUPPY'S SECRET LIFE

by James W. Atz

■ People have kept guppies as pets since 1908, and scientists have studied them for many years. Most of that time these bold, active fish have led a secret life, right under the noses of the people who were watching and breeding them. Everyone knew that guppies are born live, instead of hatching from eggs as many fish do. But no one understood their ways of reproduction. Scientists know better now, but they still have a lot to learn about the guppy.

Except for the goldfish, the guppy has for years been the most popular of all aquarium pets. It is small and hardy, and it lives well in small aquariums. Scientists use it as a sort of aquatic "guinea pig." With simple care, you too can keep guppies and investigate their lives.

Some Rules for Keeping Guppies

The water in which fish live is very much a part of their lives, and the slightest pollution can kill them. Like all fishes, guppies are sensitive to metals (especially copper, silver, zinc, chromium). Such things as disinfectants, soaps, detergents, insecticides, chlorine, tobacco, paint, and many plastics may also kill them. Try to keep everything out of the aquarium except what is definitely known to be safe. A cover of glass kept on top will help. The aquarium should be made so that only glass touches the water inside it.

Sudden changes of any kind are bad for fish, and sudden changes in temperature are often fatal. If the temperature in the room gets below 72°F, your aquarium will have to have a water heater and thermostat.

Water that comes from the faucet is perfectly suitable for people to drink, but the chlorine and metal in it may poison fish. To use such water in an aquarium, first leave it in an open glass container for a week or so. This allows the chlorine to escape into the air and improves the water greatly for fish life, especially if some aquatic plants are put into the water. This is called "conditioning."

Fish like the guppy will "condition" their own water, too, because, up to a point, their waste products will improve their environment. But too much of this waste matter will interfere with the growth and reproduction of aquarium fishes. So, every two to three weeks you should replace about one quarter of the water with fresh, clean water—conditioned, if possible.

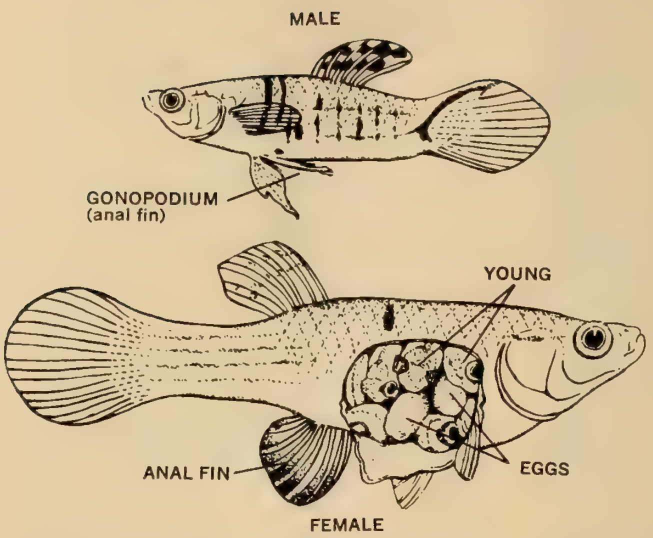
Don't leave leftover food or dead fish in the water for long; they will decay and give off substances that are very poisonous. Your aquarium should be kept clean at all times. "Vacuum cleaning" it with a siphon is the easiest way (*see "Make Your Own Sea Aquarium,"* N&S, *October 31, 1966*). If you siphon the water into a *clean glass* container, some of it may be siphoned back after the dirt has been allowed to settle out of it.

Feeding Your Guppies

Like your four-footed pets, guppies will learn to "beg" for food and sometimes act as if they are hungry even when they are not. The only way to know that fish have had enough to eat, but not too much, is to watch them

(Continued on the next page)

Dr. James W. Atz is Associate Curator of Ichthyology at The American Museum of Natural History.



This diagram compares the size, markings, and the size and shape of fins in male and female guppies. The female is drawn dissected, showing the developing young and the unfertilized eggs in the ovary.

The Guppy's Secret Life (*continued*)

carefully, making sure that they eat up every little bit that they are fed. After a while, you will learn just how much your fish will eat, and you won't have to watch every mouthful or clean up after meals.

Feed your guppies each morning to keep them breeding regularly. (Three feedings a day are not too much for young fish, but be extra careful not to overfeed them.) Use different kinds of food, both the dry and the wet (paste) kinds that are sold in pet stores. Also try some live food, such as daphnia, brine shrimp, white worms, or tubifex worms. If you can't get any live food from a pet shop, some frozen brine shrimp or daphnia may be used.

Many people believe that plants are needed in an aquarium to supply oxygen, but plants add oxygen to the water only when they are in bright light. Unless an aquarium has too many fish in it, all the oxygen that is needed will pass into the water from the air above.

A pair of guppies can live very well in a one-gallon container, but you should remove their offspring as soon as they start to grow. This will prevent overcrowding.

Guppy Courting and Mating

There is always a lot going on in a tankful of guppies. In fact, there is so much activity that it is difficult to study what any particular fish is doing. If you want to see how male guppies court females and mate with them, first put a male into a one- or two-gallon container. (The photo and diagrams will help you tell males from females.) After about an hour, the female may be added. Unless the male feels "at home," he will pay little or no attention to the other fish.

You will see a great deal of courtship activity—the male will swim around the female and turn its body into an S shape. You should not be surprised if you don't see any mating for some time. (The photograph on the preceding page shows guppies starting to mate.)

How Guppies Are Born

In the mating process, the male deposits its sex cells, called *sperms,* inside the body of the female. The sperms can live there, in the female's *ovary* (*see diagram*), for at least eight months, fertilizing batches of eggs as they become ripe. In this way, the sperms from one mating can produce as many as eight broods of guppies—one brood every 21 to 28 or more days, depending on the amount of light and the temperature in the aquarium. Once the eggs have been fertilized, the young guppies will develop in about 20 days.

Few people have ever seen a female guppy give birth to her brood. The young fish are usually born head first. It takes a minute or so for each one to come out, and two or three may appear one right after another. A female may bear 70 or 80 young within three to four hours.

One of the first things a newborn guppy must do is swim to the surface and gulp a bubble of air to fill its *gas bladder.* (This bladder is a sac inside the fish's body that helps reduce its weight and allows the fish to swim without great effort.) Until this happens, the tiny fish may be easy prey for an adult guppy, even its own mother. Some floating plants in your aquarium will provide hiding places near the surface for the young guppies ■

PROJECT

To see the developing young and the unfertilized eggs of different sizes, you may want to cut open (*dissect*) a female guppy. First drop it into ice water. When the guppy has stopped moving, carefully cut open its belly and look for the young and eggs (see *diagram*). You can also dissect male fish. Once the belly is cut open and the intestine and liver are moved aside, you may see the tiny, whitish *testis* at the top rear of the body cavity. These are the organs that produce the sperms. The microscopic sperms are gathered together in tiny whitish packets. In these the sperms travel from the testis to the male's *gonopodium* (see *diagram*), and are released from the packets inside the female's body.

🟩 For more information about raising and breeding guppies, you might send for these booklets: **All About Guppies,** by L.F. Whitney and Paul Hahnel, T.F.H. Publications, Jersey City, N.J., 1964, $2; **Know Your Guppies,** by Albert J. Klee, Pet Library, Ltd., 50 Cooper Square, New York, N.Y. 10003, 1967, $1.

Using This Issue . . .

'continued from page 2T)

Mendel's explanation of his results ed to the whole science of genetics. Discoveries since his time support his indings. In most organisms, however, he study of heredity is more complex han in the sweet peas he studied.

Take, for example, the phenomenon f "tongue-rolling" shown on the over of this issue. The ability to roll our tongue into a U shape is thought o be a simple dominant trait. Knowng this, you might expect every three ut of four people to be "tongue-rollrs." In the human population, however, the ratio of dominant-type people o-recessive-type people has no relaion to the 3:1 ratio that Mendel ound in the second generation of the eas he studied. This ratio applies nly to the particular kind of simple ross-breeding that Mendel worked vith. *(For more information about the Mendelian ratio, and about "tongueolling," see "Activities" below.)*

In Mendel's work, one trait was lominant over another *(see diagram on age 2T)*. But today geneticists know f many cases where neither trait domnates. In these cases, the offspring has "blend" of both traits (for example, color of fur that is intermediate beween the color of the parents' fur).

Mendel also encountered only two ossibilities for each trait—yellow or green, round or wrinkled, and so on. Now geneticists know that there may e three or more possibilities, or *muliple factors*. Many human characterstics, including blood types, are determined by multiple factors.

Topics for Class Discussion

• *Would it be better to study fruit lies or humans to get information ibout how traits are inherited?* The advantages of fruit flies are many: large iumbers can be easily raised and bred; nany offspring are produced; there is short time between generations.

• *How do scientists learn about lominant and recessive traits in hunans?* For knowledge of human eredity, geneticists rely on family historics and pedigrees. The information ; hard to gather and not always acurate, but from studies of large numers of families, some deductions can e made. Studies of human heredity re also complicated by the effects of nvironment, such as diet.

Activities

• Some of your pupils may have difficulty understanding the results of Mendel's experiments. If so, explain to them that the combinations of characters are based on the laws of chance, and that they can toss coins to "test" Mendel's conclusions.

Have each child take two pennies or other coins and tape a letter on each side—tape D (for round, *dominant*) on one side of each coin and R (for wrinkled, *recessive*) on the opposite sides. Then have the children flip the coins 100 times or more, keeping records of the number of times each of the three possible combinations (DD, DR, RR) appears. Don't expect the results to be in a perfect 1:2:1 ratio. The larger the number of trials, the closer to this ratio you are likely to be. Adding together all of the children's findings will probably help you make this point.

• Your class might want to find out if "tongue-rolling" *(see cover)* is a dominant or recessive trait. Use a table like the one below to record data from the class. If possible, get data from other classes to increase the size of the sample.

Class	Rollers	Non rollers	Total	% Rollers
1				

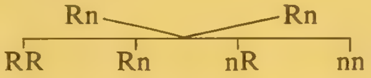
Next, have the children count the tongue-rollers in their immediate families. (Do not include families in which remarriages or adoptions are known to have occurred.) Record the data in a table like this:

	All children rollers	All children nonrollers	Children of both kinds
Both parents rollers			
Both parents nonrollers			
1 parent of each kind			

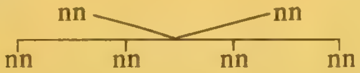
> **What about Twins?**
>
> The article "From 'Blobs' to Lions" stresses the idea that sexual reproduction insures genetic variation, with no two individuals alike. There are always exceptions, however, to generalizations about nature. In this case, the exception is *identical twins*. They begin to form when the fertilized egg first divides into two "daughter" cells. Instead of dividing again, as is normal, these cells separate and each develops into a new individual. Since they came from the same fertilized egg, each embryo has the same heredity.
>
> Identical twins often differ in some ways, however. This is due to differences in their environments, both as embryos and after birth. Fraternal twins and other multiple births are the result of multiple fertilized eggs.

Based on these observations, have the class try to determine whether tongue-rolling is dominant or recessive. Use these clues:

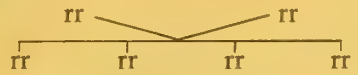
1. When a trait is dominant, two parents who show the trait *may* have children who don't show it. Your pupils can figure this out by using R (for rollers, dominant) and n (for non-rollers, recessive).



2. When a trait is recessive, two parents who show the trait can *only* have children who show it. (Remember, a recessive trait will only be shown if it is not accompanied by the dominant trait.)



Or, if tongue-rolling *were* a recessive trait:



3. Thus, a single family where both parents are tongue-rollers but at least one child is not a roller proves that tongue-rolling is *not* a recessive trait.

References

• *The Language of Life*, by George and Muriel Beadle, Doubleday & Company, Inc., New York, 1966, $5.95.

• *High School Biology — BSCS Green Version*, Rand McNally & Co., Chicago, 1963, $6.84 ($8.24 with Teacher's Manual).

• *Biological Science: Molecules to Man*, BSCS Blue Version, Houghton Mifflin Co., Boston, 1963, $7.40 ($8.60 with Teacher's Manual).

(Continued on the next page)

Using This Issue . . .

(continued from page 3T)

The Guppy's Secret Life

Goldfish and guppies are both excellent aquatic animals for classroom aquariums, and the rapid-reproducing guppy is especially useful for studying reproduction. Here is some additional information about guppy reproduction that may help you understand what you and your class observe.

The male guppy is not born with a gonopodium; this modification of the anal fin develops gradually. When the gonopodium is thrust inside the female's body for a few seconds, packets of sperms, which have traveled along a groove in its surface to its tip, pass into the female's ovary. The sperms live there for at least eight months. They fertilize batches of eggs as they become ripe, producing as many as eight broods of guppies.

You will see lots of courtship activity, but to see successful mating you should concentrate your observations during the week following the birth of the young. The females are most receptive to males then.

Depending on the amount of light and the temperature, a female guppy may have a new brood every 21 to 28 or more days. The number of fish born depends on the size and age of the mother. It may be less than half a dozen or more than 100.

If you dissect a *gravid* (pregnant) female as suggested in the article, you may find young almost ready for birth. Put them gently in the aquarium; they may survive this caesarian delivery.

As the article points out, embryo guppies develop in the *ovary* (where the eggs are produced) and get most of their nourishment from a sac of yolk. Fishes do not have a *uterus* (as humans and other mammals do) although the embryos of many species receive nourishment from the mother's body via structures that resemble parts of the uterus in mammals. The overwhelming majority of fishes, however, do not bring forth living young, but lay eggs that are fertilized externally.

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Suggestions for Observing a Partial Eclipse of the Sun on May 9

by Kenneth L. Franklin

■ A partial eclipse of the sun will be visible throughout most of North America during the early morning of May 9. Viewers on the west coast will see the moon obscure about 70 percent of the sun's disc. The percentage will lessen as the eclipse moves eastward until only about 7 per cent of the disc will be obscured to viewers on the east coast.

You can probably learn from your local newspaper or broadcasting station the time of day that the eclipse will be visible in your location. If not, you can estimate the time by using the map below. Note the time when the eclipse will be at a maximum in your area and begin your observations about 55 minutes earlier.

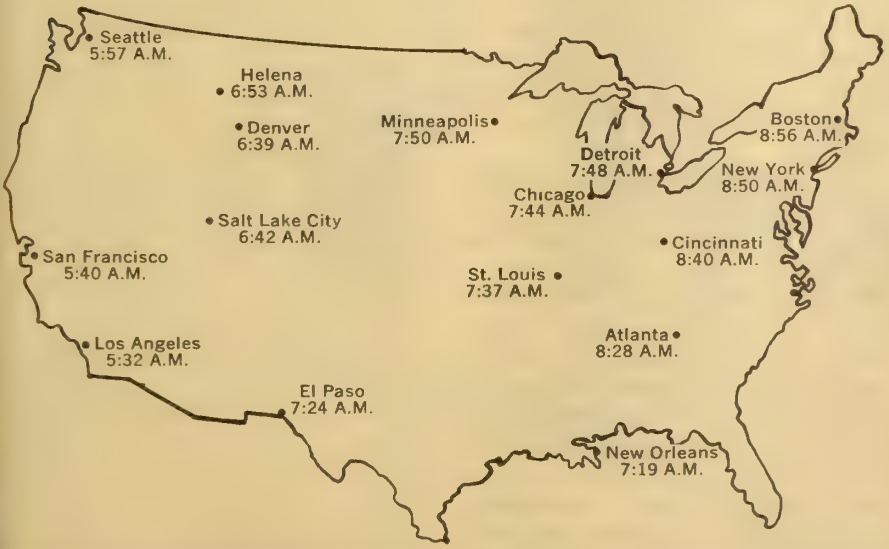
Viewing the Sun Safely

A glance at the sun is enough to make the viewer look away immediately. But an eclipse gives you a reason to look at the sun for a protracted time, and this can be harmful to the eyes. *Under no circumstances should the sun ever be looked at with the aid of opera glasses, field glasses, binoculars, or a telescope lacking special attachments.* Ignoring this warning can result in painful burns of the eye.

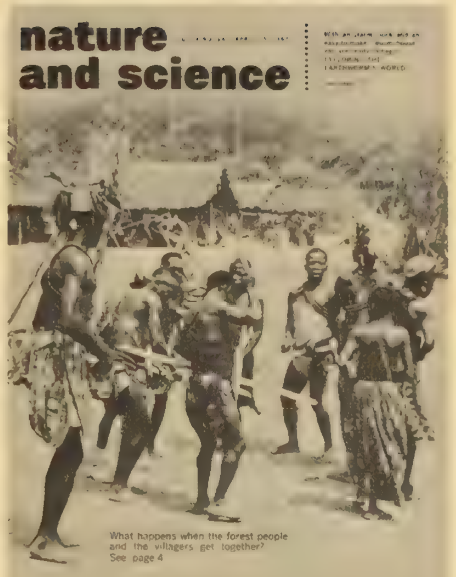
There are many ways to reduce the danger of looking at an eclipse. All

(Continued on page 4T)

Dr. Kenneth L. Franklin is an Astronomer at the American Museum-Hayden Planetarium in New York City.



The May 9 eclipse will reach its maximum at the standard times listed for each city. Note the time for the nearest city and begin observing about 55 minutes earlier.



nature
and science

What happens when the forest people
and the villagers get together?
See page 4

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Life with the Forest People**
A scientist tells how he studied the ways of a group of African pygmies.

Planting Seeds in the Spring
Your pupils can investigate what happens to seeds that are planted too early.

● **The "Spirit" That Moves Things**
This WALL CHART shows some of the ways energy is stored and changed in form as it moves things.

● **Exploring the Earthworm's World**
First of three SCIENCE WORKSHOPS showing how to investigate earthworm ecology, behavior, and anatomy.

How Much Air Do You Breathe?
Your pupils can find out by trapping exhaled breath in a plastic bag and measuring its volume.

The Possibilities in a Peanut
George Washington Carver's work with peanuts led other scientists to seek new uses for familiar plants.

How Much Food Do Animals Eat?
Your pupils can find some "hidden" information in a table of animal weights and food intake.

IN THE NEXT ISSUE

Bicycle physics... How cooperation helps the Mbuti pygmies survive and enjoy life in the forest... SCIENCE WORKSHOPS: studying bees and wasps in your back yard; testing earthworms to see if they can "learn."

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Life with the Forest People

This article serves a double teaching purpose: It introduces your pupils to a group of people whose ways have been little changed by modern technology and "civilization" and it shows them some of the problems and techniques of a scientist who studies the ways of such groups of people.

Topics for Class Discussion

- *Why does a scientist like Mr. Turnbull spend long periods of his life with a group of people like the Mbuti?* Mr. Turnbull doubted the accuracy of the few books that had been written about the pygmies and wanted to find out for himself how they live. If your pupils question whether this is a strong enough reason, point out that the Mbuti are one of the few peoples left on earth who live by hunting and gathering, as our ancestors did before farming and animal husbandry were invented (*see "When Men First Learned to Farm,"* N&S, *Nov. 14, 1966, and "From Hunting to Herding,"* N&S, *Dec. 5, 1966*). So by studying how the Mbuti live, work, and play, we can get some idea of how our ancestors lived thousands of years ago.

Ask your pupils if reading or hearing a description of something that doesn't seem to jibe with their own experience or knowledge makes them want to find out more about it—to find out what the thing is "really" like or how it "really" behaves. You might point out that ever since man invented language and began describing things in words, most of the important discoveries about our world have come from people who doubted such descriptions as "The earth is the center of the universe" or "The earth is flat" and tried to find out for themselves.

- *What are some of the problems you might face in trying to find out how other people live?* Some—such as taking care of yourself in a different environment from the one you are used to—are described in the article. But how would you set about making friends with the people, learning their language, and winning their trust so that they live "naturally" instead of "putting on an act" for you?

Some of your pupils may recall having problems like these when they moved from one place to another or when they joined a new group. How long did it take them to become "one of the group," and what did they do to win this status?

- A scientist is supposed to be as objective as possible in his work; that is, he must try not to change whatever he is studying and not to let his personal feelings affect the way he describes his observations. *Do you think Mr. Turnbull could be completely objective while living with the people he was studying?* First of all, no one can be *completely* objective about anything. When you observe or measure anything you change it a little—even if only the amount of light that is falling on it. But in living with the Mbuti as one of their group, Mr. Turnbull believes that he did not change their ways of living significantly. As for his own feelings, he says he did not try to sort them out as he wrote down the things he observed each day—it would have taken too much time even to try. When he was back in familiar surroundings with time to go over his notes, many small details that hadn't been noted, and many of his feelings, were clearly recalled, helping him to produce a "picture" of the Mbuti that anyone would find true if he lived with these people as Mr. Turnbull did.

The "Spirit" That Moves Things

This WALL CHART shows some examples of the concept that *under ordinary conditions, energy can be changed and exchanged, but not destroyed.*

Can your pupils recognize these changes and exchanges of energy in the lower right-hand illustration? Heat and light from the sun warm the air and change some water at the ocean's surface into water vapor. Cooler, heavier air in the surrounding atmosphere is pulled downward by gravity, displaces the warm air upward, and gives it kinetic energy. As the earth turns beneath it, the warm air loses heat to cold air over the mountains. The water vapor condenses, forming clouds of water droplets with potential energy. As the droplets fall (rain), some of the potential energy changes into kinetic energy, which is given to water in the lake. Falling through a pipe from the lake to the power house, the water gives some of its kinetic energy to a generator, which changes its kinetic energy into electrical energy (carried away through wires, which lose some heat to the air) and heat (carried away by the water into the river and air).

Topics for Class Discussion

- *Does the earth ever lose any energy?* Yes, some heat escapes from the atmosphere into space.
- *Can objects (matter) be changed into energy?* Yes, this is how we get nuclear energy. When atoms of the element uranium are "split," heat and other forms of energy are produced as the uranium is changed into other substances that contain less matter than before. Also, energy can be changed into matter. When protons (particles in the nucleus of an atom) are moving very fast, giving them more energy increases their *mass* (the amount of matter they contain) rather than increasing their speed.
- What does energy have to do with *"Planting Seeds in the Spring," "How Much Air Do You Breathe?", and "How Much Food Do Animals Eat?" (See articles in this issue.)* Plants need to get a certain amount of light and heat daily in order to grow. The more work you do, the more oxygen (from the air) your body needs to free the chemical energy stored in your muscles. The more active an animal is, and the faster its body loses heat, the more food it must eat to get chemical energy.

(Continued on page 3T)

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nature and science

VOL. 4 NO. 14 / APRIL 10, 1967

With an alarm clock and an easy-to-make "worm house" you are ready to begin . . .
EXPLORING THE EARTHWORM'S WORLD

see page 10

What happens when the forest people and the villagers get together?

See page 4

nature and science

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A SCIENCE ADVENTURE

Life with the Forest People

PART I

by Steven W. Morris

Listening to a mother's lullaby helped a young scientist beco friends with a group of African pygmies. While living with th he learned many of their secret ways.

■ How would it feel, I wondered, to live for a year i dense forest in Central Africa with a group of people v still live about the same way their ancestors did thousa of years ago?

I had just finished reading *The Forest People*, a fa nating book about the Mbuti, a group of pygmies liv in the Ituri Forest of the Congo *(see map)*. Pygmies o grow to about 4½ feet. Until recent years nearly all them lived in forest bands, hunting game and gather the roots and fruit of wild plants for food. Now, a few the Mbuti have intermarried with other Africans and gr their own food. But the rest still live in the forest most the time, hunting and gathering their food.

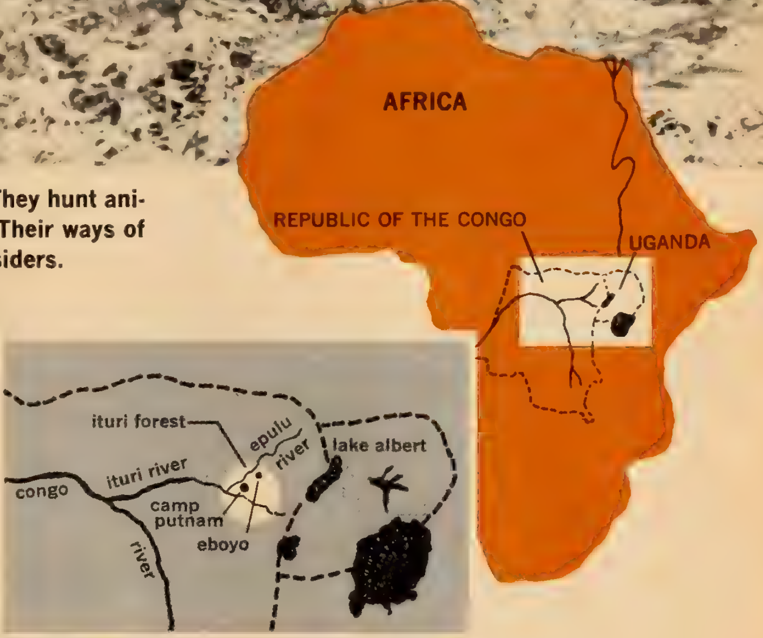
The author of this book, Colin M. Turnbull, had li with these people at three different times, for a total about three years. Mr. Turnbull is an *ethnologist*, a sci tist who studies the ways of living of groups of people. find out more about his experiences while living with Mbuti, I visited Mr. Turnbull at The American Muse of Natural History, where he is now Associate Curator African Ethnology.

Why Study Africans?

"I got interested in Africa by accident," Mr. Turnb said. "Sixteen years ago I was studying philosophy a music at a school in India. When the time came to retu home to England, I decided to take a side trip and dr through Africa. Part of the trip took me along the Ep River in the Congo." *(See map.)*

Twenty-five years before Mr. Turnbull took his trip, American named Patrick Putnam had traveled to

est camps like this are built by Mbuti pygmies in a few hours. They hunt ani- s and gather vegetables nearby until they decide to move on. Their ways of ng are screened by the forest and have been little known to outsiders.



lu to study the people there. He liked the area so much t he made it his home. Later, he and his wife built a ge mud house, and a village known as Camp Putnam w up around it. He made part of the house into a hos- l. Another part was opened as a hotel, and the money tors paid helped Putnam pay for hospital supplies.

aid Mr. Turnbull: "When I stopped off at Camp Put- n some pygmies were visiting there from the forest. One I heard a pygmy woman putting her child to sleep by ing to him. The song was strange and beautiful. I n't understand the language, but I wrote down the nds.

When I sang the song the woman became terrified. She amed. She thought I was trying to steal the child by ting on paper the song that she had made up for it. A aby is only for the person who makes it up; no other my will sing that song.

Once I made the pygmies understand what I was do- they were happy that I was so interested in their ic. After that I listened to as much of their singing as I ld and wrote it down. But when I wrote down other gs than the lullabies, the pygmies didn't like it. I finally ned why. A pygmy told me that his people don't sing r best—their "real" music—when they are in the village. wanted to hear the real music, I would have to come n them into the forest. I did, but I didn't have nearly ugh time to learn as much about the music as I wanted decided that some day I would come back."

Back in England, Mr. Turnbull read books about Africa. Very little had been written about pygmies, and some of this seemed wrong.

"I read that pygmy music was very simple and was almost always played on instruments instead of sung. I didn't think this was true. The European person who wrote this had lived in Africa for years, but had not spent enough time with the pygmies or gone with them into the forest.

"This same person wrote that the pygmies were slaves to the normal-sized villagers. He said the pygmies followed the village customs and beliefs because they had few of their own. To find out whether this was true, I had to go back to the Ituri Forest."

Return to Africa

Mr. Turnbull saved his money, and three years later he made his first trip back to Africa. He planned to stay a year.

(Continued on the next page)

These two Mbuti are being paid in food by their villager "owner," who also supplied the clothes they wear in the village. If the villager died, these Mbuti would be expected to work for his son when they were in the village.

Life with the Forest People (continued)

"At Camp Putnam I again met some Mbuti pygmies who said they would take me deeper into the forest. I wasn't sure what kind of food I'd be able to get in there, so I took with me some rice and other foods that would last, plus some notebooks, a few extra clothes, and a blanket.

"I hadn't learned the Mbuti language yet. No other people speak it. But some Mbuti men know KiNgwana, a language that is used by traders in many parts of Africa. While I slowly learned Mbuti, I spoke mostly in KiNgwana.

"It turned out that the forest is full of vegetables and berries that people can eat. There are so many animals that the pygmies, with their special hunting ways, have meat almost every day.

"The temperature in the forest stays between 70 and 85 degrees all day, much cooler than in the open country where trees don't shield you from the sun. At night you think you'll freeze without a blanket.

"From the time I entered the forest I kept a small notebook ready at all times. Whenever anyone said anything or did anything, I wrote it down. Sometimes note-taking was very hard—for instance, on a hunt, when I might have to move around very fast. At these times I would just concentrate on what was happening, and then after things quieted down I would jot down in spare moments what I remembered.

"During their religious ceremonies I was embarrassed to take notes, but I did anyway. You can imagine how you would feel if you were in church during a service and someone was watching you and writing in a notebook as fast as he could. But the pygmies never seemed to mind."

Why Be Afraid in the Forest?

Many people would be afraid to travel in the deep African forest no matter who they were with. They would be sure to carry a gun. Why didn't Mr. Turnbull take one?

"It never occurred to me that traveling in the forest would be more dangerous than anywhere else," he said. "Most animals will run away when they know a man is coming. You almost never see a snake in the forest, or any other game for that matter. You hear it, but you don't see it. I've met leopards several times, but they just look at you and go away. To get one to bite you, you would practically have to go up and step on its tail. And if you did that, things would happen so fast that you wouldn't have a chance to use a gun.

"You have probably heard stories about African tribes who often kill people. Some of these stories are true. A herder, such as a Karamojong, who lives on the plains and raises cattle, becomes more respected if he kills someone who owns many cattle. But I had nothing to fear. I didn't own any cattle, so a herder wouldn't bother to kill me. A pygmy will not kill anyone for any reason.

"Besides animals and some tribesmen, what outsiders seem to fear most about the forest is disease. Actually, the pygmies who live in the forest live longer than many people in other parts of the world. Few flies and mosquitoes are in the deep forest, so pygmies don't often catch

ABOUT THE COVER

The cover photo shows Mbuti pygmies taking part in the first dance of a sacred festival called *nkumbi*, at the village of Eboyo, about 25 miles from Camp Putnam. Sabani *(left)*, the village chief, is leading the dance. The other man with a feathered headdress is also a villager. He is dancing in the circle with young Mbuti men who have been initiated in earlier nkumbi. You can see a few women in the background, but they are not allowed to enter the nkumbi area.

the diseases they carry such as malaria [*see "Men, Mosquitoes, and Malaria,"* N&S, *January 9, 1967*]. The water is almost never polluted, so there is no danger from water-borne disease. If a pygmy does not die of some childhood disease, he has a good chance of living into his sixties.

"I myself was sick only once—and that happened in the village at Camp Putnam. On the second day of a visit there I woke up in the morning and found that I couldn't stand. My knees wouldn't hold me. I didn't feel any pain, and all my other joints were all right. When afternoon came I still couldn't walk. Some pygmies cut sticks for me to hobble on, but I wasn't good at it. Mrs. Putnam drove me 70 miles to a government hospital where doctors gave me medicine. After that my knees were all right, but for two weeks I was weak and had a high fever. I still don't know what that illness was.

"These may seem like exciting adventures to you. They were to me, too. But also exciting was the chance to learn about the life of the pygmies, which has been hidden from outsiders for so long."

I asked Mr. Turnbull how the pygmies could hide their lives even from the other Africans who live in the Ituri Forest. He explained that the other Africans do not live in the forest itself, but in cleared areas surrounded by forest. The villagers fear the forest, and spend little time in it.

Pygmy Make-Believe

"One event showed me clearly how wrong outsiders' ideas of the pygmies were," Mr. Turnbull said. "It was a village festival called the *nkumbi.* During this festival, which lasts several months, boys about 10 years old are kept in an area outside the village and go through hard, painful training that is supposed to toughen them into men. The Mbuti, whom the villagers think of as something like servants *(see photo),* come to the village to take part in the nkumbi. The year I was there, no village boys were the right age for the nkumbi, so only eight pygmy boys took part. According to the sacred rules, their fathers were allowed to live in the nkumbi area with them, but nobody else. The pygmies and I convinced the villagers to let me stay in the area too.

This young Mbuti hunter is smoking meat to take to a nearby village. If Mbuti get a lot of meat during a hunt, they often share it with villagers.

Colin M. Turnbull recently returned to The American Museum of Natural History in New York City from Uganda *(see map)*, where he lived for 18 months with mountain tribesmen. He was born in London and has spent eight years in India and Africa.

"In the daytime, village men came in to lead the training of the boys. The boys had to be cut once with knives, and then were made to dance and sing *(see cover).* Their beds were split logs with a rough frame over them to keep off the rain. In eating, they could not use their hands to pick up food, but had to spear it with sticks. Their fathers were forbidden to comfort them at any time.

"Each night, though, after the villagers had left the nkumbi area, the boys got out of their beds, ate with their fingers, and joined their fathers around the fire. They played and made fun of the nkumbi and the villagers.

"After the nkumbi was over and the pygmies returned to the forest, the boys were still treated as children, and were not allowed to sing the parts of the pygmy songs that are for men. As far as the pygmies are concerned, the nkumbi does not "make the boys into men," as the villagers believe.

"To the villagers, and to outsiders living in the village, it had appeared that the pygmies believed in the nkumbi. But I lived through the whole nkumbi with the pygmies, and I could see that the pygmies do not believe in the nkumbi or in the village gods. They had pretended to go through the nkumbi only because they knew it would make the villagers easier to get along with and because it helps toughen up the youngsters." ■

In the next issue, Mr. Turnbull discovers how the Mbuti catch animals with nets, and why they sing their complicated "real music" only in the forest.

PLANTING SEEDS IN THE SPRING

by Deana T. Klein

■ If you plant seeds too early in the spring, they may be killed if the temperature drops below freezing. Yet, seeds of many plants stay "alive" for a long time even when exposed to very low (or very high) temperature. What is it about planting seeds early that leads to their death?

You can find out by experimenting with some corn seeds. (You'll need about 150 seeds and you can get them from a garden supply store or grocery store.) Instead of actually planting the seeds, however, you can try to create spring soil conditions for them in your own "lab." For example, when seeds are planted in the spring, the soil is usually moist. From the soil, the seeds take up water through a process called *imbibition.* The imbibed seeds swell as they take in water.

You can duplicate the conditions of moist soil by soaking corn seeds overnight in tap water. Be sure to use a large container and a large volume of water because corn seeds swell a lot as they imbibe water. Soak about half of your corn seeds in this way.

Next, divide the dry seeds into three equal groups with at least 25 seeds in each group. Divide the imbibed seeds the same way. Then get six shallow containers, such as plastic sandwich boxes–one for each group of seeds. Put one group of dry seeds and one group of imbibed seeds in separate containers; then put them in the freezer compartment of a refrigerator and leave them there for one hour.

Put another group of dry seeds and a group of imbibed seeds in separate pint jars. Add 2 cups of water to each jar of seeds. Put the jars in a pan of water, set it on the stove, and heat the water to about 140-145 degrees F. Use a candy-maker's thermometer to measure the temperature. Keep the seeds at this temperature for one hour.

Put the remaining groups of dry and imbibed seeds in separate shallow containers. They are the "control" on your experiment, neither refrigerated nor heated.

After an hour, take the seeds from the freezer. Add ¼ cup of water to each box and put it in a warm, dark place like a cupboard. Next take the two groups of seeds from the jars of warm water and put the seeds in separate shallow containers. Add ¼ cup of water to each and put them in a warm, dark place. Finally, add ¼ cup of water to the control groups of seeds and put them with the others. Be sure to put labels on each box that describe the treatment for that group of seeds.

How Many Sprout?

Look at your seeds every day. Add more water to the boxes if they begin to dry out. The control groups of seeds will sprout, or *germinate,* in three to five days. When most of the control seeds have germinated, "harvest" your experiment. Count the number of seeds that have germinated in each group. You can put the numbers in a table like the one shown below. You can also figure out the percent of each group of seeds that germinates in this way:

$$\frac{\text{Number of seeds germinated in group}}{\text{Total number of seeds in group}} \times 100 = \text{per cent germination}$$

Now compare the percent of germination in the six groups of seeds. What conclusions can you make from your findings? What happens when seeds are planted too early in the spring?

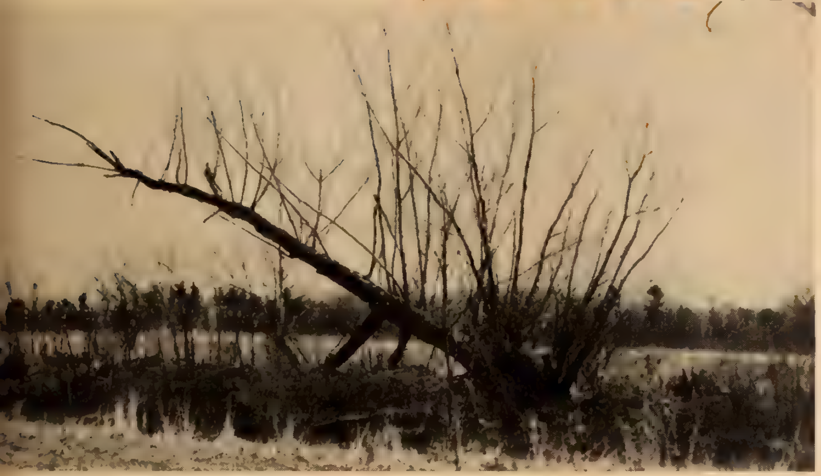
Suppose you had left the imbibed seeds and the dry seeds in the freezer for only 15 minutes. Would this change the result of the experiment? Would it make any difference if the seeds were frozen for a day or a week? Try it and see. Suppose you had used boiling water (212°F) instead of water at 140°F. Would this change the results of your experiment? There are many ways in which you can change this experiment to investigate the effect of temperature on seeds ■

Dr. Deana T. Klein is a member of the faculty of the Biology Department of Hunter College, City University of New York, Bronx, New York.

	TREATMENT								
	HEAT			COLD			CONTROL		
SEEDS	NUMBER GERMINATED	TOTAL NUMBER	PERCENT GERMINATED	NUMBER GERMINATED	TOTAL NUMBER	PERCENT GERMINATED	NUMBER GERMINATED	TOTAL NUMBER	PERCENT GERMINATED
DRY									
IMBIBED									

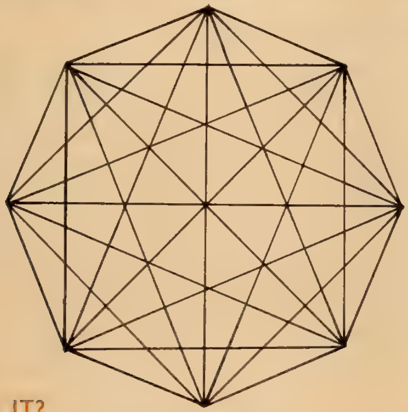
brain boosters

prepared by **DAVID WEBSTER**



MYSTERY PHOTO

What caused the tree to grow in this unusual shape?



CAN YOU DO IT?

Can you count the number of lines in the figure above?

Submitted by Daniel Chapman, League City, Texas

WHAT WILL HAPPEN IF?

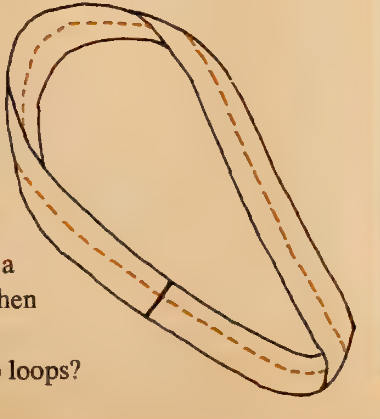
Ask your mother if you can place some soil in a pan lined with aluminum foil and heat it in your oven. What will happen to the soil? Will the soil change color or smell?

JUST FOR FUN

Make some mud pies. See how many different kinds of soil you can find, and try making a mud pie with each kind. Are some kinds of soil better for mud pies than others?

FUN WITH NUMBERS AND SHAPES

Make a loop of paper with a half twist (*see diagram*). Then cut the strip apart along the dashed line. Do you get two loops?



FOR SCIENCE EXPERTS ONLY

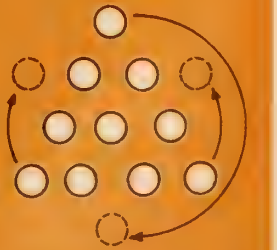
A man was sentenced to die, but was allowed to decide if he would be hanged or shot. He had to make a statement, and if what he said were true, he would be shot. If he said something that was false, however, he would be hanged. After thinking a moment, the man made a statement that made it impossible for him to be shot or hanged. What did he say?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The Mystery Photo was taken looking up between two concrete pillars of a high bridge.

Can you do it? To get an ice cube with a penny inside, first make half an ice cube. Then put the penny on the ice, add more water, and freeze it again. What will happen to the penny as the ice melts?

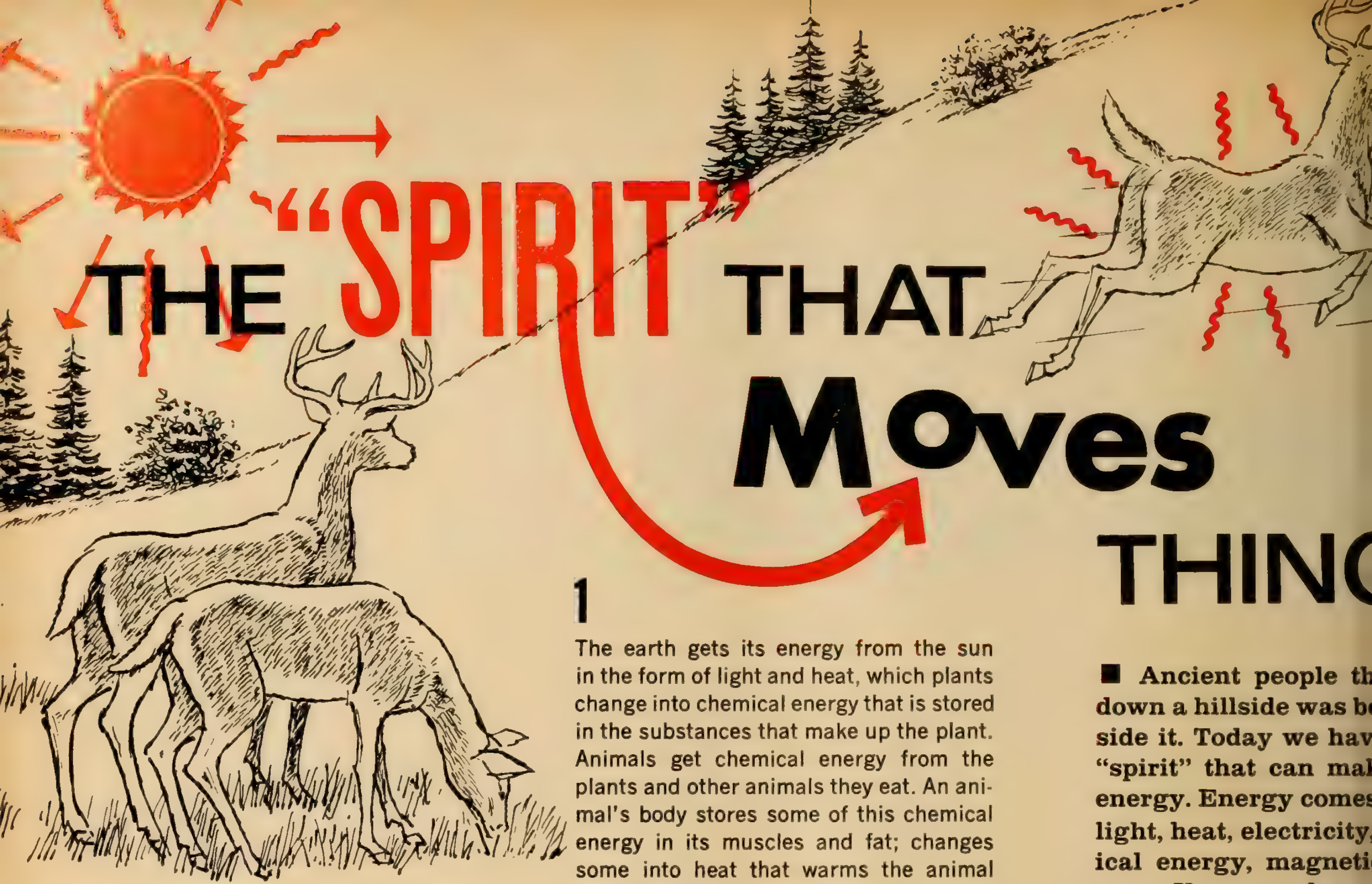
What will happen if? A bathroom scale will show your whole weight even if you stand with one leg in the air. What will the scale do if you jump off?



Fun with numbers and shapes: The drawing shows how to reverse the pattern of 10 pennies.

For science experts only: In order to get the most hours of daylight in a year, you could live at the North Pole from March 21st to September 21st. Then you could travel to the South Pole and stay there for another six months.

THE "SPIRIT" THAT Moves THIN

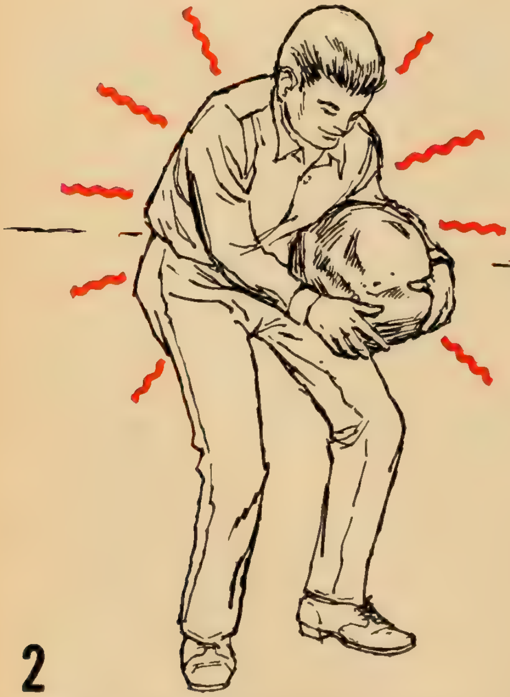


1

The earth gets its energy from the sun in the form of light and heat, which plants change into chemical energy that is stored in the substances that make up the plant. Animals get chemical energy from the plants and other animals they eat. An animal's body stores some of this chemical energy in its muscles and fat; changes some into heat that warms the animal then escapes into the air; and changes some into mechanical energy to move the animal around.

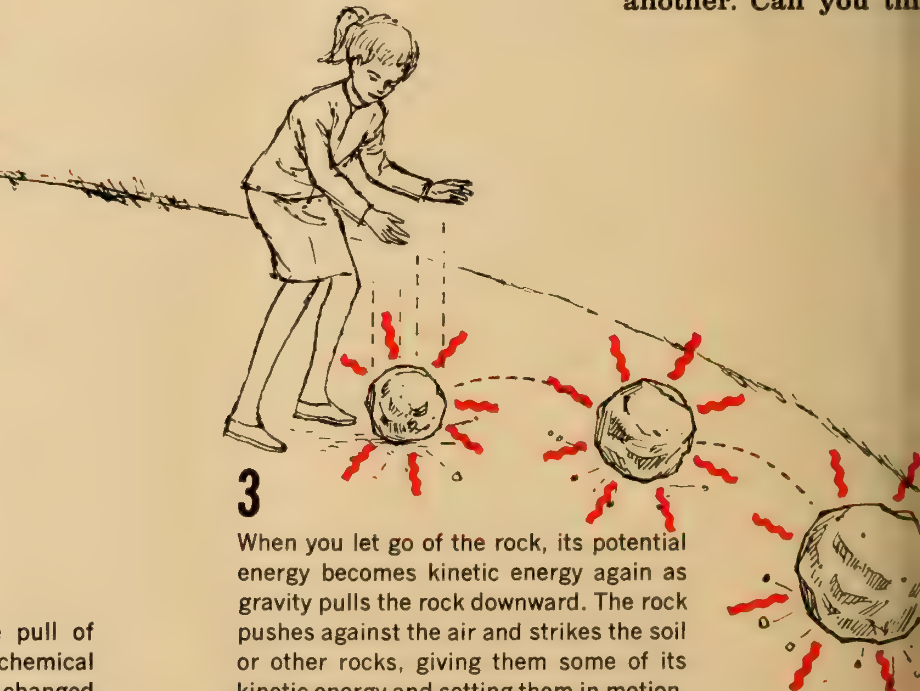
■ Ancient people th down a hillside was b side it. Today we hav "spirit" that can ma energy. Energy comes light, heat, electricity ical energy, magneti ergy. You can chang another form, but you

This WALL CHAR ways that energy is c another. Can you thi



2

When you lift a rock upward against the pull of gravity, you have to "spend" some of the chemical energy stored in your muscles. Some of it is changed into heat that warms the air around you. Most of it is changed into a kind of mechanical energy called *kinetic* energy, or energy of motion, in your moving arm. This energy changes into another kind of mechanical energy called *gravitational potential* energy that is "stored" in the rock.

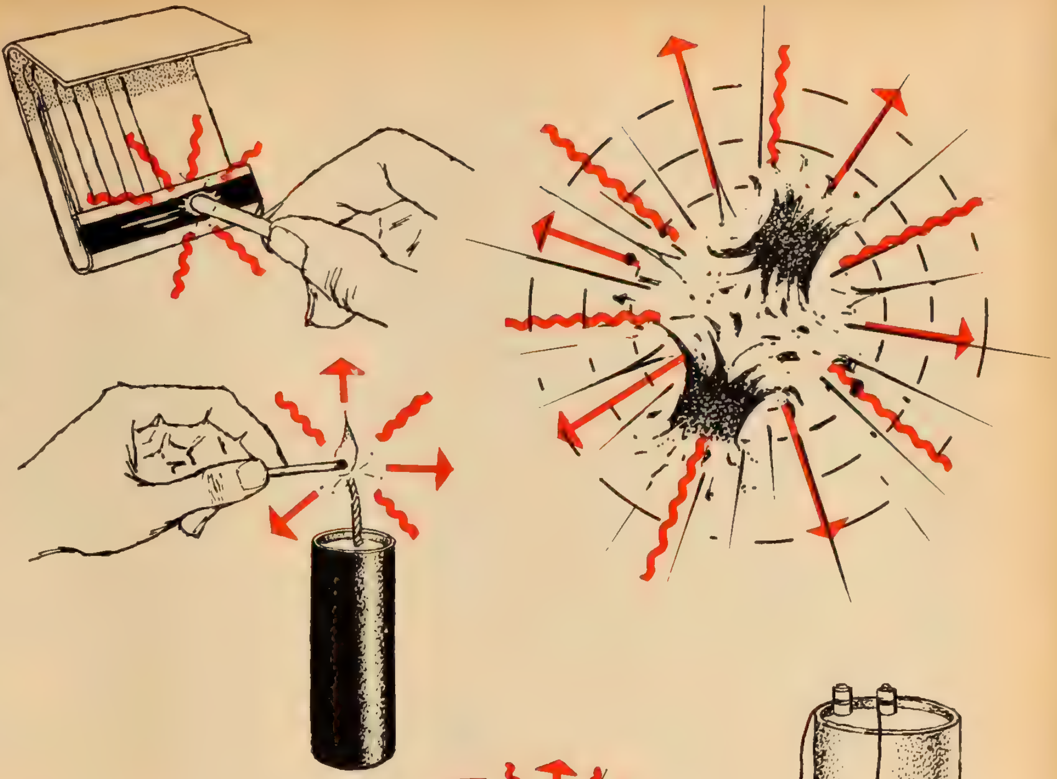


3

When you let go of the rock, its potential energy becomes kinetic energy again as gravity pulls the rock downward. The rock pushes against the air and strikes the soil or other rocks, giving them some of its kinetic energy and setting them in motion. All of these objects rub against each other and against the air, causing *friction*, which changes some of their kinetic energy into heat. When the objects stop moving, do you think they have any energy left?

4

When you strike a match, kinetic energy is changed to heat through friction. This heat changes the chemical energy stored in the matchhead into heat and light. The flame's heat changes the chemical energy in a firecracker into still more heat, a little light, and a lot of kinetic energy as the heat pushes the firecracker apart in all directions. The particles give some of their energy to the air as heat and some as kinetic energy that moves the air particles and makes sound waves.



a rock sliding
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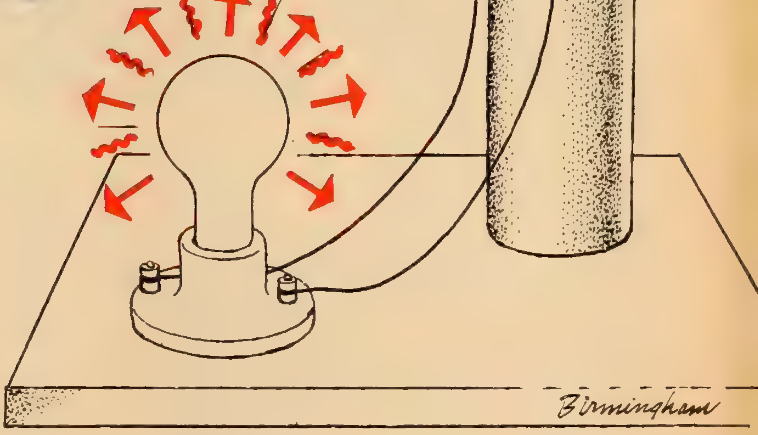
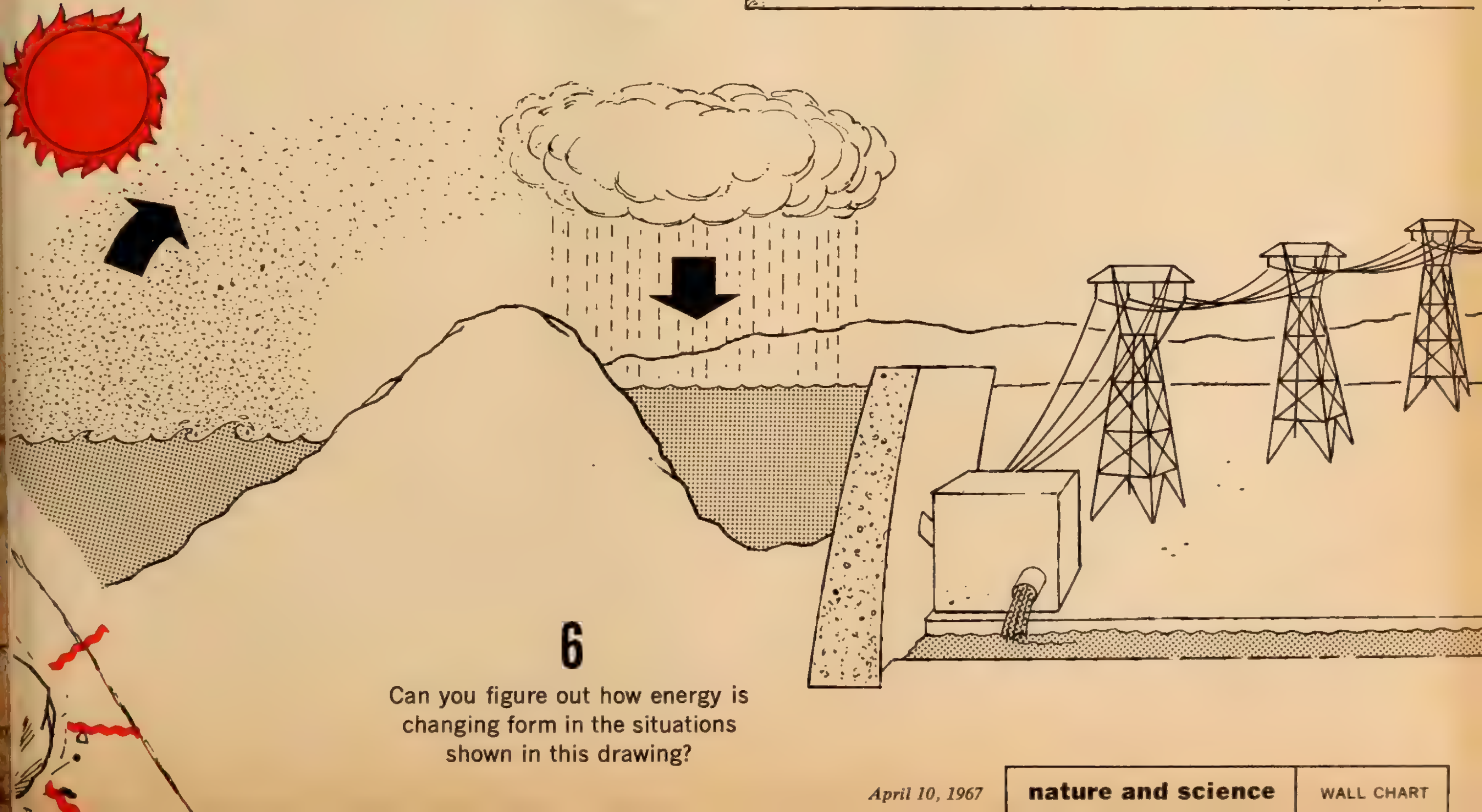
5

A battery has a kind of chemical energy called *electrical potential.* When you connect it to a light bulb, this potential energy is changed into electrical energy that pushes tiny particles called electrons through the wires. The wire inside the light bulb resists the flow of the electrons, causing a kind of friction that changes their electrical energy into light and heat. Can you think of a way to change electrical energy into kinetic mechanical energy?



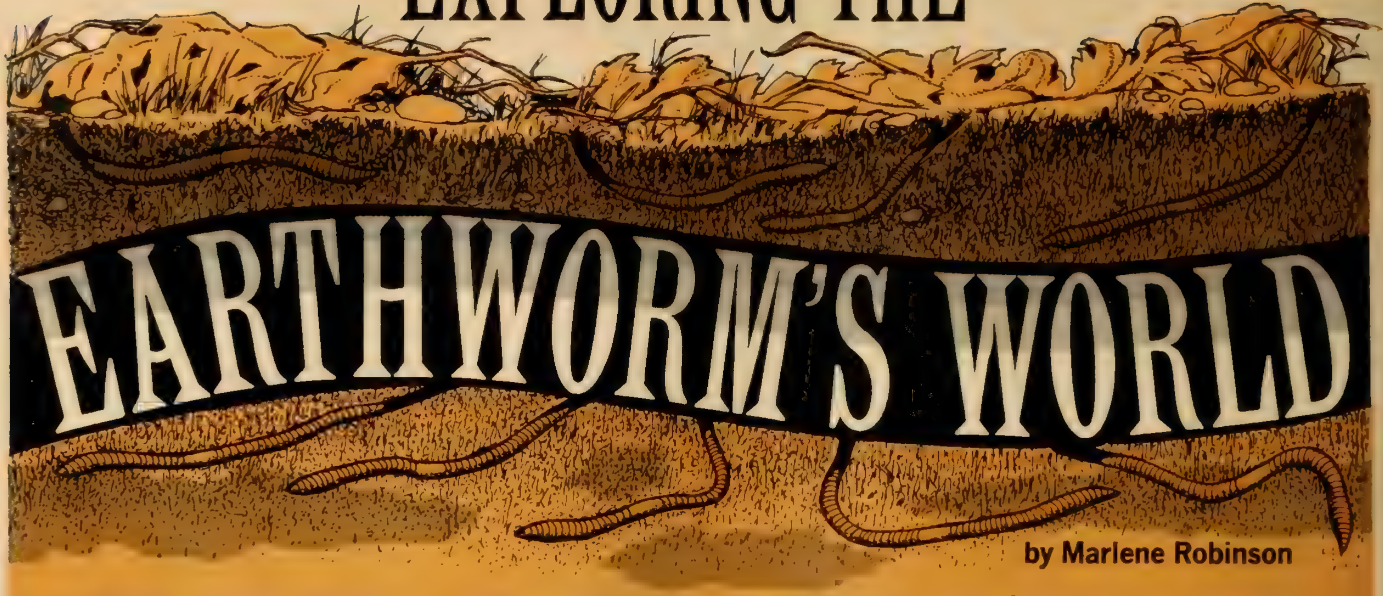


6

Can you figure out how energy is changing form in the situations shown in this drawing?

Part 1

EXPLORING THE EARTHWORM'S WORLD



by Marlene Robinson

You can probably find some of these crawly creatures in your own back yard or in a nearby lot or park. Part 1 of this three-part article tells how to collect some earthworms, set up a home for them, and begin to investigate their lives.

■ "Ugh!"

Is that the way you feel about earthworms? If so, you should read this article just to find out about the lives of these squirmy animals. If, on the other hand, you want to collect and study worms, this article will tell you how.

To get and keep a healthy collection of worms, you will need to give them the things they are used to in nature. I will suggest some ways for doing this; you may think of others. To learn about the needs of earthworms, you should observe carefully and take notes as you collect your worms.

Before you start collecting worms, build a home (called a *vivarium*) for them. The kind shown in Diagram 1 will allow you to watch earthworms at work.

Once the vivarium is ready, go on a hunt for worms. Take along an alarm clock, a small scoop or trowel, some small plastic bags, a small plastic bottle of water, and a notebook and pencil. Also get some *litmus paper*. This special paper, available from drug stores, comes in strips of pink or blue. The blue paper turns pink when it is dipped in an acid solution. The pink paper turns blue when it is dipped in a basic, or *alkaline*, solution *(see "Cabbage Chemistry,* N&S, *Feb. 27, 1967).* You can use litmus paper to find out if earthworms live in acid or basic soil.

Sound the Alarm for Worms

Look for an area covered with dead leaves. Then lift some of the leaves to reach the soil beneath. Put the thermometer on top of the soil, but beneath the leaves. Begin your notes with the date and location and then write down this first temperature reading. Next sink the thermometer about two inches into the soil to find the temperature there. Stand up and take another temperature reading at about your eye level. This way you can mark the reading as taken at your own height. These readings may tell you something about the temperature needs of earthworms.

As you clear away a patch of leaves, stuff a few handfuls of these into a plastic bag. Try to find out what kind of leaves they are. Earthworms "like" some leaves better than others. Biologists have discovered that earthworms are not usually found among oak leaves or pine needles. Mash some leaves in a little water and test this liquid with litmus paper. Are the leaves acid or alkaline?

To actually see some worms, use the alarm clock. Wind the alarm of your clock and set it off. Then press the *face side* against the soil. This is a sure way of getting whole worms and it allows you to collect worms even in parks where no digging is allowed.

It is not the sound itself that makes the worms leave their tunnels and crawl to the surface. Touch the clock lightly with your fingers while the alarm is ringing. What you feel is what the earthworm feels all over its body. It apparently makes the worm uncomfortable and it tries to get away from that feeling. Do you suppose earthworms can feel your footsteps when you walk on the ground?

Collect about two dozen worms as they come to the surface. Also collect some of their *castings*. These are pellets of soil and plant material that have passed through the bodies of earthworms.

If you look carefully through a magnifying glass at castings, you may find earthworm egg sacs. They are like tiny rubbery balloons that are the color of the soil. Actually these balloons hold many eggs. Even if you don't see these, you may later discover you have young worms in your earthworm vivarium.

What Holds a Worm?

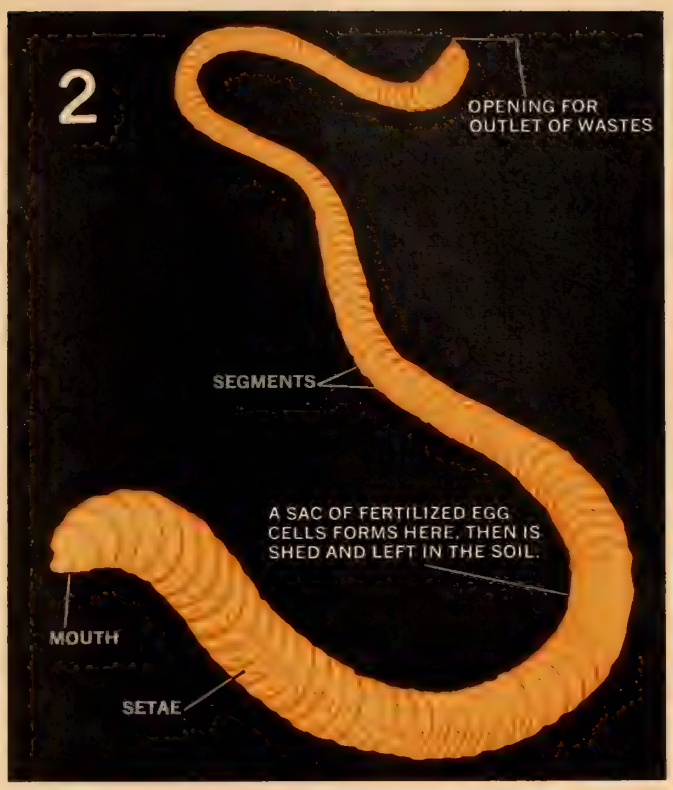
After you have collected your worms, dig down in the soil a bit. Investigate the earthworm tunnels. Look for other animals besides worms that live in the same kind of soil. Also look for a worm that is half-out of its burrow. Try to pull it out the rest of the way.

What holds the worm? You can find out by running your fingers down the length of a worm, from head to tail. Next run your fingers the other way, from tail to head. What you feel are bristles that are almost like feet. They're called *setae (see Diagram 2).*

Look at these with a magnifying glass. Are setae found all around the worm or just on one side? Why?

Somewhere nearby you may find a patch of an entirely different kind of soil. Inspect this for living things, for types of leaves, and for worms, too. Collect some of this

(Continued on the next page)


2
OPENING FOR OUTLET OF WASTES
SEGMENTS
A SAC OF FERTILIZED EGG CELLS FORMS HERE, THEN IS SHED AND LEFT IN THE SOIL.
MOUTH
SETAE

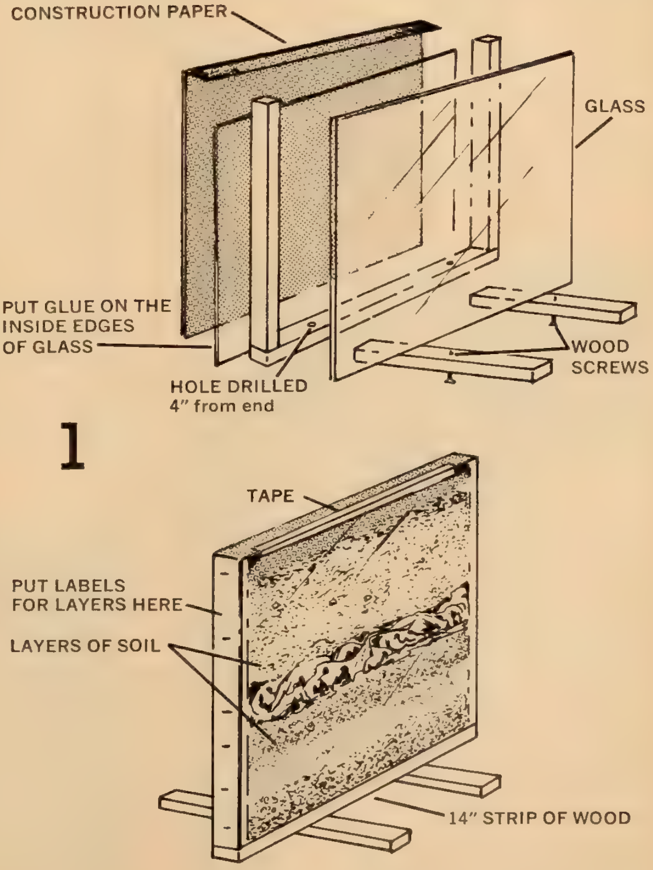
A HOME FOR WORMS

Before you go collecting worms, build a home (called a *vivarium)* for them. The kind shown in the diagram will allow you to watch your worms at work.

To make a vivarium, all you need is two panes of glass and five strips of wood, plus two wood screws and glue. You can buy glass (12 inches by 14 inches) ready-cut in a hardware store. The wood strips should be no wider or deeper than three-fourths of an inch. Get four strips 12 inches long and one strip 14 inches long.

Begin building by drilling a hole four inches in from each end of the 14-inch strip. Now drill holes of the same size in the center of each of two 12-inch strips. Insert the wood screws through the 12-inch strips into the 14-inch strip as shown in the diagram. This is the base and stand of the vivarium. (You may have to gouge out the wood around the screw holes on the underside so that the heads of the screws rest flat with the base.)

Spread glue (a milk-based kind, such as Elmer's) along the inside edges of one pane of glass. Do not glue the top edge. Hold the glass up against the 14-inch strip and place the 12-inch strips in place *(see diagram).* Hold them tightly to the glass for a minute, then fasten them to the glass with masking tape, allowing the glue to dry overnight. Do the same with the second pane of glass and your vivarium is ready.


CONSTRUCTION PAPER
GLASS
PUT GLUE ON THE INSIDE EDGES OF GLASS
WOOD SCREWS
HOLE DRILLED 4" from end
1
TAPE
PUT LABELS FOR LAYERS HERE
LAYERS OF SOIL
14" STRIP OF WOOD

soil in a plastic bag. In your notebook, compare this soil with the soil where you first found earthworms. Write down as many differences as you can discover. Does one kind of soil contain more rocks? Is one more sandy, or more moist? Is it beneath a pine or oak tree? Maybe it is being washed away by the rains, or trampled by feet.

Take out your bottle of water and the litmus paper. Put a few grains of a kind of soil in the bottle cap and mix it with a few drops of water. Test with the litmus paper. Is it acid or alkaline?

In this way, test and collect as many different kinds of soil as you can find. Look for yellowish soil near rocks. Look for hard packed soil along a road. Keep notes on each type and keep the soils in separate plastic bags.

Into the Vivarium

When you get home, count the worms and measure them by counting the number of segments in each *(see Diagram 2)*. Adult earthworms have 115 to 200 segments; the young have less. Do you have a young population or an old population of worms?

Put the different kinds of soils into the vivarium in layers, making each layer at least an inch deep. Put the "worst" soil (for instance, the hard packed soil from a path) on top. Use leaves as one layer. Mark these layers on the side of the vivarium, as shown in Diagram 1. This will help you find out what layers the worms choose to live in and whether they mix the layers.

Pour a glassful of water on the top layer of soil and put the worms in the vivarium when all the layers are moist. How long does it take for the water to soak through? Each week you will need to add some more water to keep the layers moist. Note the time it takes each week for the top layer to let the water pass through. Does it always take the same amount of time?

When you add the worms it may appear that they do not like their new home at first. If they knit themselves into a ball on the surface, watch carefully to see what the worms on the bottom of the bundle are doing.

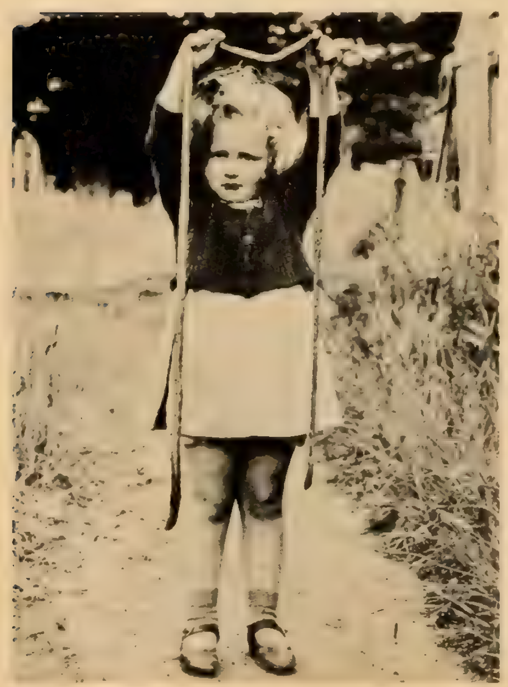
Cover the open top and one side of the vivarium with construction paper. This will give the worms a dark side and a light side.

Although the layers of soil and the layer of leaves provide food, you can offer other foods as well. Occasionally put in some lettuce, cabbage, celery leaves, carrot scrapings, or even bits of hamburger. Put these in the same corner of the vivarium every time. After two weeks or so, shift the food to the other corner. Do the worms find them as quickly?

As you watch your worms day by day, try to find out how they make castings. How do they move through the soil? How do they eat? Watch the mouth of the worm as it works against the glass, searching for food.

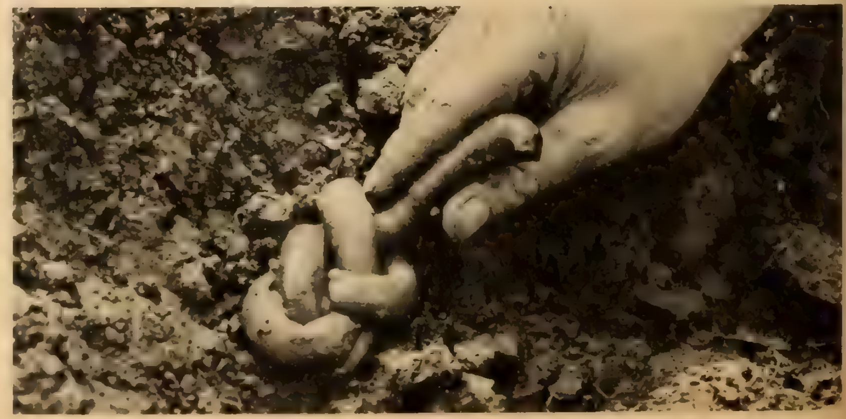
Keep your earthworms healthy by providing them with food and moisture. Also try to keep the vivarium at the temperature you found when you explored the earthworm's world ■

In the next issue, Part 2 of this article tells how you can build a maze and find out how and what earthworms learn.



WORMS BY THE YARD

This Australian girl is holding a giant earthworm from Gippsland, Victoria, Australia. These worms grow to be as long as 12 feet. They may be three-quarters of an inch in diameter and weigh a pound and a half. The photo below shows how some Australians reportedly catch the giant earthworms—tieing a knot in one end of the worm to keep it from pulling back into its burrow.



HOW MUCH AIR DO YOU BREATHE?

BY ROBERT GARDNER

■ Most of the time, we don't even notice that we are breathing; yet, we are continually taking air into our lungs (*inhaling*) and releasing air from our lungs (*exhaling*). Here is a way to find out how much air you breathe each day.

First of all, you can find out how much air you breathe in and out with each normal breath. You will need a plastic bag, a wax crayon or a marking pen, and a plastic pail that has lines on it to mark the number of quarts in the pail. (If you don't have a marked pail, use a large jar or can that you can mark yourself. To do this, pour a pint or quart of water into the container and make a mark on the side at the water level. Pour in another pint or quart and make another mark. Continue to do this until the container has been marked all the way to the top.)

After you squeeze all the air out of the plastic bag and pour water into the container up to the 2- or 3-quart mark, you will be ready to start.

Hold your nose so that all the air you are breathing is passing through your mouth. Inhale and exhale a few times until you are breathing at a normal pace. Then place the opening of the empty plastic bag firmly against and around your mouth just before you start to exhale. Collect the air you exhale in the plastic bag. (Do not *blow*—just exhale normally.) Twist the end of the bag to seal in the air you have collected. You can seal the "neck" of the bag by twisting a piece of wire around it or by holding it tightly.

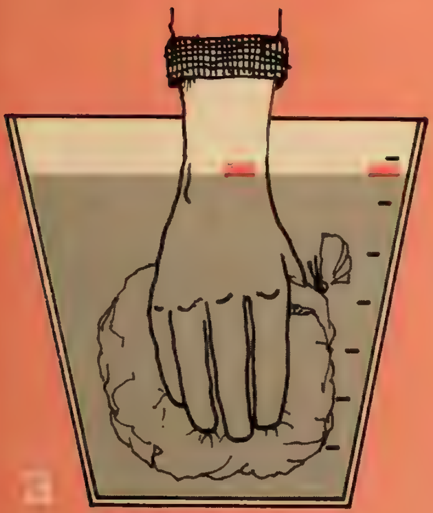
To find out how much air you exhaled, push the bag of air into the container so that all of it is under water (*see Diagram A*). Mark the level of the water on the container, and mark your wrist at the point where it goes into the water.

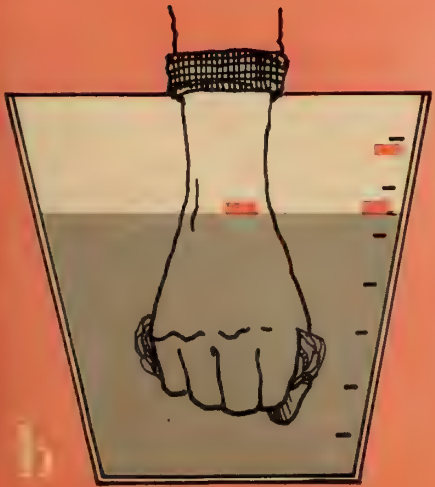
Now squeeze all of the air out of the bag, hold it in your fist, and push your hand and the empty bag into the water again, up to the mark on your wrist. Mark the level of the water on the container (*see Diagram B*). How much of the rise in the water level was caused by your hand and the bag? How much air did you breathe into the bag?

Counting Your Breaths

How many times do you normally breathe each minute? Have someone time you as you count your own breaths. Would it be a good idea to do this several times, at least a few minutes apart, and find the *average* number of breaths you take in a minute?

Can you figure out about how many times you breathe each hour? Each day? Since you now know how much air you inhale and exhale with each breath, you should be able to figure out about how much air you breathe each day ■



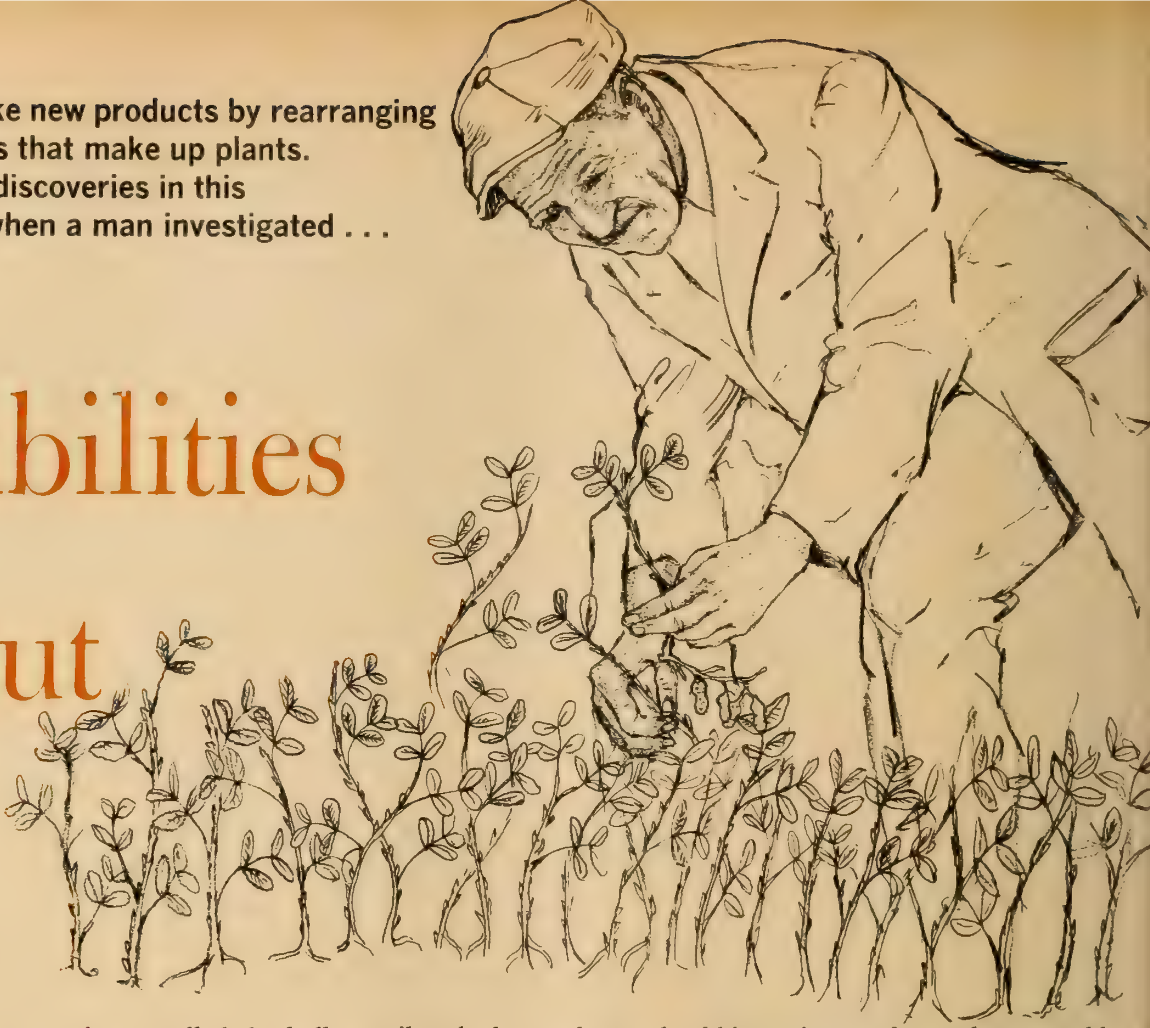


INVESTIGATIONS

- How does the volume of air your parents breathe with each breath compare with yours?
- Compare the volume of air you breathe after exercising with the amount you normally breathe.
- Do boys breathe faster than girls? Slower? At the same rate? Do babies breathe at a different rate than people your age? How about adults?
- Take a deep breath and then exhale as much air as you can into a large plastic bag or balloon. How does this volume of air compare with the amount you *normally* breathe? How does your deep breath compare with those of your classmates? Your teacher? Your parents?
- Do you breathe slower when you are asleep? Ask your mother or father to count how many times you breathe in a minute at night after you have gone to sleep.

Chemists can make new products by rearranging the chemical parts that make up plants. Some of the first discoveries in this field were made when a man investigated . . .

the possibilities in a peanut



■ Early in this century, an insect called the boll weevil began attacking the cotton crops of North America. As the insect advanced from Mexico to Texas, farmers in the southern United States realized that they had made a great mistake. Cotton was a valuable crop and many farms grew only cotton. If the cotton plants were wiped out, many people in "cotton country" would be ruined.

The threat of the boll weevils was eventually brought under control by use of chemical poisons. But many farmers, merchants, and bankers were ruined. Many farms were abandoned. The people had learned a lesson—not to depend so much on a single crop.

One man who had long talked against relying so much on cotton was a scientist named George Washington Carver. A former slave, Carver had worked his way through college. Then he taught and studied at Tuskegee Institute in Alabama.

As he traveled the countryside, Carver encouraged the farmers to try new crops, such as soybeans and peanuts. He tried to find uses for plant parts that were going to waste. Cotton stalks, for example, were left to rot in the fields. Carver showed how they could be used to make paper, or fiber rugs. Through most of his nearly 50 years at Tuskegee, Carver was especially interested in the possibilities of one plant—the peanut.

Carver was a chemist. In his early days at Tuskegee he had to make much of his equipment from whatever odds and ends he could find—ink bottles, bits of wire and rubber, teacups. He got glass tubing from a medicine bottle and used a flatiron to crush substances.

The Parts of a Peanut

Working in his simple laboratory, Carver began to study peanuts. First he removed the shells and skin. Then he started "breaking down" peanuts into their basic chemical parts. As he took the peanuts "apart," he found water, fats, oils, gums, sugars, starches, and other substances. "There," he said, "I had the parts of the peanut all laid out before me."

Other scientists before Carver had discovered that the peanut was made of such parts. But Carver went a step further. He began to put the parts back together again, in new combinations.

Carver found that he could use the oil in peanuts to make margarine. The fat from peanuts could be made into a kind of milk. The cream that rose to the surface of this milk could be turned into butter, buttermilk, or cheese. Carver discovered more than 100 ways to prepare peanuts as food. Once, for an important luncheon at the Tuskegee Institute, a girl's class prepared 14 different kinds of food —all containing peanuts—including soup, imitation chicken, salad, bread, candy, cookies, ice cream, and coffee.

Carver also found ways to change the chemical parts of peanuts into baby oil, axle grease, pickles, bleach, soap, paper, ink, plastics, shaving cream, linoleum, and shampoo. Most of the 300 products he made were never produced outside of his laboratory. (Many cost more to make from peanuts than from other raw materials.) But some are still made from peanuts today.

When Carver began his work with the peanut, the plant was used mainly as food for livestock. Not many were grown. But as Carver's work revealed new uses for peanuts, the plant gradually became an important crop in the United States.

New Uses for Plants

Carver wasn't the first man to try new ways of using familiar plants. For thousands of years some plants have supplied men with dyes, paper, perfumes, cloth, drugs, or fertilizers. Some of these uses have been discovered by accident. As men learn more about chemistry, however, they are finding new ways of turning the raw materials of plants into useful products. This is called *chemurgy*.

Carver was one of the first scientific chemurgists. His work was a step forward in *synthetic* chemistry—the branch of chemistry that takes apart the materials found in nature and puts their elements back together in new combinations. (The earth contains more than 100 different *elements*, including oxygen, hydrogen, sulfur, iron, copper, and carbon. Most of them are combined with other elements in substances called *compounds*.)

Every day you see and use some results of man's work with synthetic chemistry—in clothing, packages, paints, furniture, toys. Most synthetic chemistry today makes substances from the elements found in petroleum and coal. (Most plastics come from these materials.) But once a barrel of petroleum is used, it can't be replaced. Eventually the earth's supply of petroleum and coal, called *fossil fuels*, will be used up.

Plants, however, can keep producing new plants that can supply more raw material for synthetic chemistry. In the future, plants may prove to be the most important "ingredient" for synthetic chemistry. And chemists will trace the study of chemurgy back to the peanut, and George Washington Carver ■

For more information about George Washington Carver and his work, look for this book in your library or bookstore: **George Washington Carver: The Story of a Great American,** by Anne Terry White, Random House, New York, 1953, $1.95. For more information about chemistry, see these books: **All About the Wonders of Chemistry,** by Ira Freeman, Random House, New York, 1954, $1.95; **First Chemistry Book for Boys and Girls,** by Alfred Morgan, Charles Scribner's Sons, New York, 1950, $1.25 (paper).

It was in this lab at the Tuskegee Institute that George Washington Carver (left) used simple equipment to break down plants into their chemical parts. By putting the parts together in new ways, he found new uses for the plants.

HOW MUCH FOOD DO ANIMALS EAT?

by David Webster

■ The table on this page shows how many pounds of food are eaten each day by different kinds of animals. This information came from zoo keepers and farmers who keep records of how much they feed their animals.

The animals have been listed in order of their weight. To help you compare the amount of food eaten by different animals, the table also gives the weight of food eaten for each 1,000 pounds of the animal's body weight. For example, the giraffe weighs 2,000 pounds and eats about 36 pounds of food a day. This means it eats 18 pounds of food per 1,000 pounds of body weight. A pig weighing 200 pounds eats 8 pounds of grain. At this rate, five pigs would weigh a total of 1,000 pounds and would eat 40 pounds.

Do Big Animals Really Eat More?

As you would guess, large animals eat more food each day than smaller ones eat. However, the table shows that many smaller animals eat more food per 1,000 pounds of body weight than larger animals eat. For example, a tiger weighs six times as much as a lamb, but a tiger—in a zoo, at least—eats about the same weight of food per 1,000 pounds of body weight as a lamb eats. In this case, one reason is that the lamb is still growing, and part of its food goes into building materials for its body. But there are other reasons why many small animals eat more food than larger animals compared with their body weight.

The food that an animal eats gives it energy to move around and heat to keep its body warm. Birds and many small mammals often are more active than larger animals, and their bodies tend to lose heat faster through their skin. This is because a small animal's body has more skin area for its *volume,* or bulk, than a larger animal's body has (*see "The Case of the Pale Sparrows,"* N&S, *December 5, 1966*). Also, an animal may have to eat a greater weight of one kind of food to get enough energy and heat than if it ate another kind of food. And some animals do not get as much energy as others do from the same kind and same amount of food.

You may have noticed in the table that the alligator and the snake eat very little food for their body weights. Both are reptiles, and reptiles get most of the heat they need from outside of their bodies—by basking in the sunlight, for example—instead of from the food they eat ■

How Much Food do YOU Eat?

Can you guess how much food you eat? (Hint: What animal on the table weighs about the same as you do?) One way to get a rough idea of how much you eat is to weigh yourself on a bathroom scale before you eat and again after you eat. Do this at breakfast, lunch, and dinner, and add up the weights of everything you eat in a day.

If you have a pet cat or dog, try to measure its food intake, too.

ANIMAL	APPROXIMATE WEIGHT IN POUNDS			KIND OF FOOD (IN ZOOS AND ON FARMS)
	ANIMAL	FOOD EATEN PER DAY	FOOD EATEN PER 1,000 LBS. OF BODY WEIGHT	
ELEPHANT	4,700	94	20	VEGETABLES, HAY
HIPPOPOTAMUS	4,000	49	12	VEGETABLES, HAY
GIRAFFE	2,000	36	18	VEGETABLES, HAY
CAMEL	1,400	38	27	HAY
COW (MILKING)	1,200	45	38	GRAIN, HAY
HORSE	1,000	18	18	GRAIN, HAY
BEEF STEER	1,000	25	25	GRAIN
COW (YOUNG)	800	22	28	GRAIN, HAY
GORILLA	450	20	44	MEAT, FRUIT
LION	350	8	23	MEAT
ALLIGATOR	300	2	7	MEAT
TIGER	300	12	40	MEAT
SNAKE (PYTHON)	225	¼	1	CHICKEN
PIG (ADULT)	200	8	40	GRAIN
DEER	150	4	27	GRAIN, HAY
KANGAROO	125	4	32	VEGETABLES, HAY
SEAL	100	6	60	SQUID, FISH
SHEEP	100	3	30	GRAIN, HAY
WOLF	90	3	33	MEAT
PIG (YOUNG)	50	3	60	GRAIN
SHEEP (LAMB)	50	2	40	GRAIN, HAY
PENGUIN	32	3	90	FISH
TURKEY	25	3/5	24	GRAIN
PELICAN	18	4	222	FISH
RACCOON	15	1	66	VEGETABLES, FISH
DUCK	7	½	71	GRAIN
CHICKEN	5	⅓	67	GRAIN
HAWK	4	¼	63	RODENTS
RABBIT	4	¼	63	VEGETABLES
PARROT	2	1/10	50	SEEDS

Can you find the answer to these questions by studying this table? 1. Do birds eat more than mammals? 2. Do meat-eating animals eat less than animals that eat plants? 3. Does an animal eat about the same amount of food when it is young as it does when it is an adult?

Using This Issue . . .

(continued from page 2T)

The Earthworm's World

This first in a series of three SCIENCE WORKSHOPS tells how to investigate the worm's environment. By observing the conditions where worms are found and by keeping worms in a vivarium, your pupils will learn about the earthworm's needs of light, moisture, temperature, food, and soil chemistry.

Earthworms are part of the soil community. They depend on the soil environment for food, protection, and for reproduction. In turn, they have an important effect on the formation and structure of soil. They influence the lives of other animals and plants and are a part of many food chains.

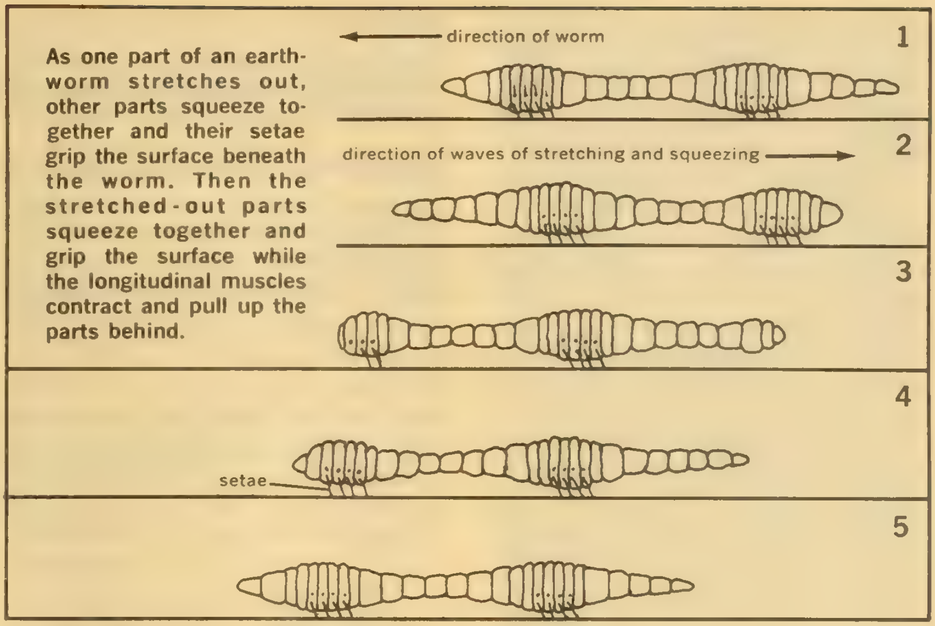
Most of the earth and plant material that passes through a worm's digestive system is deposited on the ground as castings. In this way, earthworms bring to the surface an estimated 7 to 18 tons of soil per acre each year. Their burrows also admit air and aid in drainage.

Your pupils can observe the effect of earthworms on soil after the worms have been in the vivarium for a few weeks. The compacted soil of the top layer will improve with time; you will probably notice that water soaks through it faster.

Topics for Class Discussion

- *Why are earthworms easy to find after a heavy rain?* Some children may suggest that the worms must come to the surface to escape drowning in their burrows. Actually, worms can live for a long time in water, so long as it has enough oxygen dissolved in it. But rainwater loses its oxygen as it filters through the soil and earthworms must either dig deeper or come to the surface to get more oxygen. Many of these worms die from predation or from prolonged exposure to light.
- How do worms move? Earthworms have two main layers of muscles, one circular and one longitudinal. When some of the circular muscles contract, that part of the worm gets thinner and longer. When the longitudinal muscles contract, they make the worm thicker. As the worm moves along, waves of thinning and thickening seem to travel along its body. But this alone doesn't move it.

In order to move along the ground, the worm must be able to hold on. The tiny bristles called *setae* serve as anchors for the parts of the worm that are not thinning or thickening *(see diagram)*. To illustrate the importance of the setae, put a worm on a sheet of glass or other surface where its setae cannot grip.



As one part of an earthworm stretches out, other parts squeeze together and their setae grip the surface beneath the worm. Then the stretched-out parts squeeze together and grip the surface while the longitudinal muscles contract and pull up the parts behind.

Activities

Some of your pupils might want to try some summer studies of the effects of earthworms on soil and plant life. For example, take cuttings of geraniums or coleus and plant some in pure earthworm castings, others in compacted soil. Give all the plants equal water and sunlight. Then, after a month or two, compare their leaf color, growth, and root systems.

Someone might also try comparing the growth of two groups of plants, one grown in soil containing earthworms, the other growing in identical soil without earthworms.

Reference

- *The Earthworm,* by Albert Wolfson and Arnold Ryan, Harper and Row, New York, 1955, $2.40.

About the Earthworm Science Workshops

Last summer a course for teachers conducted at the Riverdale Outdoor Laboratory in the Bronx, New York, sought to develop activities that would bring the world of nature into the classroom. The focus was on projects for "depressed" areas. What objects from the outdoors can beneficially be studied indoors in a big city? The earthworm is one. Easily found and kept, it affords a great variety of activities.

Mark, a fourth-grader from Harlem, happened upon some worms during our first hour of exploring the Riverdale acreage.

"I ain't used to touching these things!" he squealed as he held one at arm's length upon the trowel.

By the end of six weeks, Mark was an earthworm expert. He had a vivarium full of worms. He had observed, measured, experimented with, and dissected others. He knew their basic parts. He knew just where to look for earthworm homes.

Mark didn't like to verbalize his actions, but with help he could recall the logic that led him to the worms: ". . . . look for cool(ness) where it's wet . . . moist . . . look for dark places under leaves . . ."

When Mark looked at the parts of the earthworm, he automatically compared what he found to his own body structure. He especially had fun trying to move his muscles, indeed, his whole body, like an earthworm.

These activities gave him confidence in his own abilities, and led him quite naturally to books for more information. These articles developed out of experiences with Mark.

—MARLENE ROBINSON

Observing an Eclipse . . .

(continued from page 1T)

these ways reduce the amount of energy from the sun that can reach the eye, and most of them involve the use of some sort of filter. For instance, try several thicknesses of exposed and developed black-and-white photographic film. Before the eclipse, experiment with the film to learn how many thicknesses you need to cut down the sun's light to a comfortable level. Then cut a round hole in a piece of cardboard and tape the film across the hole. This will provide a simple viewer which is convenient to handle.

The homemade smoked glass traditionally recommended for viewing an eclipse is usually not satisfactory, because the smoking process is messy and the darkening of the glass is very uneven.

If you are in a place sheltered from the wind, you can watch the eclipse as reflected in a glass dish of water. Place the dish over a sheet of black construction paper to provide a dark background. Again, you will have to protect your eyes with some kind of light filter, but not so thick a filter as when viewing the eclipse directly. Very dark glasses or polaroid glasses may be used satisfactorily.

Another Way To Watch the Eclipse

The view you will have of the eclipse through any of the systems mentioned above will be essentially an unaided-eye view. To present a more pleasing picture, there is a way to use optical aid. By cutting a hole of proper size, slip a large piece of cardboard over the upper end of a telescope or over one tube of a binocular. The object of the cardboard is to provide shade below the instrument.

Now point the instrument backward over your shoulder and toward the sun. (This will require practice, because you cannot look through the instrument, so work this out before the morning of the eclipse.) Sunlight will come out of the eyepiece and make a spot of dim light on the floor or ground.

Hold white paper or cardboard about a foot below the eyepiece to form a screen upon which you can focus the image of the sun. The focussing may be done in the usual way, by adjusting the eyepiece in or out or by turning the central knob of the binocular. You may have to have help in doing this.

A Danger To Avoid

The objective lens of the telescope collects the light of the sun and concentrates it in a small area, which is the telescope's focus. This forms the solar image. This "hot" image is near the eyepiece inside the tube of the telescope. The eyepiece spreads the light out to an image much larger than the size of the objective. The heat and light per square inch in this image is less than that falling on the objective lens. Thus, there is no danger to the screen or for anyone watching this image on the screen.

However, if you allow the concentrated image *inside* the telescope to stray from its path through the eyepiece, it can heat the telescope tube or the eyepiece mounting enough to cause damage. For this reason, keep the sun's image falling neatly on the screen, or direct the telescope away from the sun when you are not projecting an image ■

• •

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nature and science

TEACHER'S EDITION

VOL. 4 NO. 15 / APRIL 24, 1967 / SECTION 1 OF TWO SECTIONS

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◀N & S REVIEWS▶

Some Recent Physical Science Books for Your Pupils

by Fred C. Hess

ACTIVITIES BOOKS

Safe and Simple Projects with Electricity, by Charles Neal (Childrens Press, 157 pp., $4.50) is an excellent manual. It contains a brief history of electricity and a good set of definitions of electrical terms. It presents two dozen well illustrated projects in electricity. Text and illustrations are well matched. Directions are clear. A section on general tips on project preparation is most valuable. Useful for intermediate level elementary pupils.

Setting Up a Science Project, by Ann Stepp (Prentice-Hall, 56 pp., $3.50) is an extremely helpful type of book for pupils in intermediate elementary grades. It covers the general area of preparing science projects, not by suggesting projects, but by discussing each developmental step. It clearly illustrates the differences between what is good and what is not likely to arouse interest. It leads the student away from the common mistake of trying to do something too big, too general. Contains a brief index.

Science Experiments with Water, by Sam Rosenfeld (Harvey House, 190 pp., $5). The experiments are mainly physical, rather than chemical. The principles upon which the experiments are based are described briefly, and the scientists who discovered the principles are identified. The section on perpetual motion is not well done. In general, the book has good illustrations, a glossary, and an index. It is a source of projects for pupils in upper elementary grades.

Winter Science Activities, by John M. Youngpeter (Holiday House, 128 pp., $2.95) has strong appeal, not only because it contains 70 projects which are well within the capability of the elementary pupil, but also because it teaches the child what to look for in the wintry environment. Many of the projects can be carried out by city dwellers. Contains a bibliography and an index.

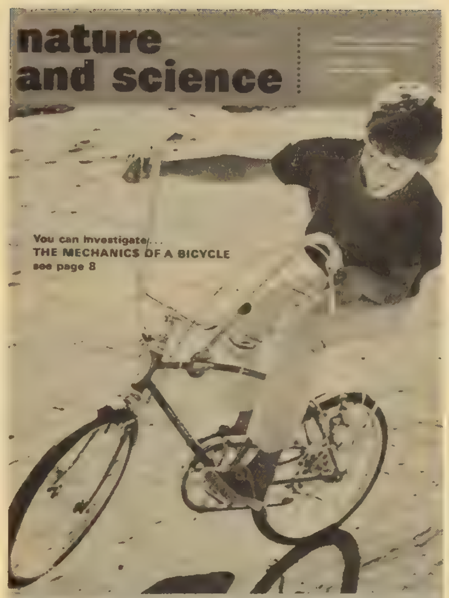
Learning About Science Through Games, by Warren Goodrich (Stackpole Books, 108 pp., $2.95) is more likely to be useful to teachers, counsellors, or recreation directors who work with young children. Science-based games are described, followed by an outline of principles involved. Sets of games are organized around physical fields: mechanics, heat, etc. It has an excellent glossary.

INFORMATION BOOKS

Sound, by Henry Brinton; **Electricity,** by Walter Shepherd; **Light and Color,** by Frederick Healey; and **Telescopes and Observatories,** by Patrick Moore (Golden Press, 48 pp., 50 cents each). These four paperbacks are part of the "Finding Out About Science" series. With easy-to-read text and colorful and pertinent illustrations, the authors develop their subjects for intermediate elementary grade

(Continued on page 3T)

Dr. Fred C. Hess is a Professor of Physical Sciences at State University of New York Maritime College, Fort Schuyler, N.Y.



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Why Sing Before a Hunt?**
An anthropologist who lived with African pygmies notes similarities in the ways they sing and hunt.

● **Teach a Worm To Turn**
Your pupils can investigate the sensitivity of earthworms to different stimuli by testing the worms in a simple T-maze.

The Mechanics of a Bicycle
The vehicle we all take for granted can be used to illustrate many physical principles.

"Hobby Horse" to "High Rise"
A brief history of the bicycle shows how inventors arrived at the design of today's bikes.

How It Works—Electric Meter
Your pupils can learn to read the meter and find out how much electricity their families use.

● **Secret Lives of Wasps and Bees**
Many kinds of solitary bees and wasps build nests in hollow twigs. By making artificial nest sites, your pupils can learn about the lives of these insects.

IN THE NEXT ISSUE

How the war against sea lampreys in the Great Lakes is being won . . . Dissecting an earthworm . . . Speeding up a chemical reaction . . . When do wild flowers grow tallest? . . . Spirals in nature . . . Index to *N&S*, Volume 4.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Why Sing Before a Hunt?

In the last issue, Colin Turnbull described how he studied the ways of a band of African pygmies while living with them. In this issue, the anthropologist tells how these freedom-loving, individualistic people cooperate with each other in the vital work of hunting as well as in singing complicated songs.

Topics for Class Discussion

- *Why do you think the pygmies usually hunt together, instead of each one hunting only for his own family.* By combining their nets and working together, they can catch more game at one time and kill larger animals with their simple weapons. This hunting method is a *cultural adaptation* that has helped the pygmies as a group to survive down through the ages.
- *Can you think of ways that you and your friends work together as the pygmies do when hunting? How about grown-ups?* Singing or playing musical instruments in a group calls for cooperation, whether you are in an African forest or Kansas City. (We usually depend on a permanent leader for direction, while the pygmies sing their complicated songs without a leader.) The members of a well-trained basketball or football team work together in somewhat the same ways that pygmies do when hunting.

Grown-ups often work in teams (astronauts, policemen, firemen, businessmen, scientists, and campaigners for public office, to name a few), but nearly always one member is in charge, directing their work. The amount of training a team needs depends on how important it is for each member to do the "right" thing at the "right" moment without direction from the leader.

- *Do you think that the things you do help train you for adult life as the young pygmy's activities do?* Having a strong, healthy body is just as important for us as it is for the pygmies; no matter what kind of work one does, he can do it better and live longer if he keeps in good physical condition. The pygmy must "know the forest" to survive in it; the more we know about the people and things around us, the better we are able to get along in our world.

Most people don't have to hunt or raise their own food in the United States, but it's important to learn how to buy food, what kinds to eat, and how to prepare them. Learning how to work and play with other people helps us throughout life. While the things one learns in school may sometimes seem "useless," most of them are important to help us live a full and productive life in our complex society.

Activity

Your pupils probably have sung a round, such as "Row, Row, Row Your Boat," or "Three Blind Mice." You might have them try to sing in hoquet form. Divide the class into three groups, A, B, and C. Have each group sing the word or words listed under its group designation below, line by line until the song is completed.

A	B	C
Three	blind	mice
three	blind	mice
see	how they	run
see	how they	run
they	all ran	after the
farmer's	wife she	cut off their
tails with a	carving	knife did you
ever	see such a	sight in your
life as	three	blind
mice		

If your pupils have trouble with this, you might have all the girls sing the song straight through, accompanied by three groups of boys singing the song in hoquet form, as described above. (Then have the girls accompany the boys.)

If everyone feels brave, try to combine round and hoquet singing. Use six groups, with groups A, B, and C singing in simple hoquet, and groups D, E, and F beginning when group A starts the third line.

Teach a Worm To Turn

This SCIENCE WORKSHOP offers opportunities for studying worm behavior and for organizing data. As your pupils conduct learning trials with the T-maze, they can record the results in simple charts or graphs. One simple method for graphing the data from the experiments is to let one inch of a strip of colored paper represent one minute of the trial. The result of several trials will be a bar graph.

Your pupils have probably had some experience in training puppies or other animals. The type of training with pets and earthworms is called *conditioning,* with the animal learning a correct response either by being punished or rewarded. The most famous conditioning experiments are those of Russian scientist Ivan Pavlov, who taught dogs to salivate at the sound of a bell (the sound of the bell was associated with food).

Both Yerkes and Heck removed the brain and nerves from the first five body segments of worms that had learned to turn correctly in the maze. They found that the worms continued to respond correctly, and untrained worms could be trained with their brains removed. This means that the nervous system of the body segments must be involved in learning, along with the brain.

Heck also found that a trained worm could unlearn fairly quickly. He switched the position of the dark alley and the electrodes so that the learned turn led to the electrodes. The worms reversed their learning in many fewer trials than had been needed to learn the original turn.

Remind your pupils that their bodies respond to stimuli in much the same way as an earthworm does, with the stimulus causing an impulse that eventually prompts a reaction, such as movement of a muscle *(see diagram on page 3T).* *(Continued on page 3T)*

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Build some simple nests and see what you can discover about

THE SECRET LIVES OF WASPS AND BEES

see page 13

You can investigate...
THE MECHANICS OF A BICYCLE
see page 8

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Life with the Forest People, Part 2

Why Sing Before a Hunt?

by Colin Turnbull

**In the last issue, Mr. Turnbull told how hearing
pygmy lullaby led him to study the lives of thes
African people. Living with them in a tropical fores
he found clues to why they only sing their "real
music there.**

■ The Mbuti pygmies of the Ituri Forest in the Congo didn
mind my coming to live with them. They accepted m
quickly—partly because I was willing to carry my ow
belongings, eat the same food they eat, and sleep o
leaves or branches in the frail but comfortable homes th
make from sticks and leaves.

Pygmies do not live in strict tribes in which each perso
is assigned to a certain job, such as hunter, fruit gathere
or weaver. The pygmy band is just a number of famili
who agree to live together. There are no chiefs or medici
men or official "wise men"; each person is as importa
as anyone else in the band. Each adult is "mother" o
"father" to all of the children, so any child may enter a
house and expect to be fed and taken care of.

From earliest childhood, the pygmy's life trains him t
be strong and to know the forest. At the same time,
trains him to work with all the other members of his ban
whether they are hunting animals for food or singing con
plicated songs.

Singing for the Forest

Whenever an Mbuti sings, he is not doing it just to plea
himself or the people who hear him, but also to "awake
the forest." The Mbuti think of the forest as somethin
like a parent, who gives protection, food, and life. By sin

This article is adapted from the author's books, The Forest Peopl
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Library, Garden City, New York) and* Wayward Servants, *cop
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Garden City, New York).*

These Mbuti pygmies are holding tight to an antelope that is still kicking after its throat has been cut. The animal was killed after it was driven into the hunters' nets by the women and children.

g, an Mbuti lets the forest know what he is doing or inking about, so that the forest will help him.

Mbuti music is some of the most beautiful and compli- ited I have ever heard. Most of the songs are sung in a ecial way that we call *round* form. After a person or nall group has sung a few words of a song, another per- n begins singing the same song, either with the same otes or in higher or lower notes. Then a third may begin nging, and so on. I have sometimes heard 16 voices nging at once. (Two songs you may know that are sung a simple round form are "Row, Row, Row Your Boat" d "Three Blind Mice.")

Some Mbuti songs have *solo* parts where one person one sings the melody, but he is always accompanied by chorus, and the solo part is always passed around so that person sings the whole song completely alone.

Hunting songs and some others are made even more fficult by singing them in *hoquet (ho-kay)*. Each person small group sings only one note of the song. Then a fferent person or group sings the next note, and so on. he singers sit or stand in a circle. As the song is passed ound the circle in the clockwise direction, the same song it with different notes may be passing around counter- ockwise. But always all the notes must blend together in pleasing sound.

Singing is often accompanied by beating sticks together hitting drums. Wooden whistles are sometimes blown, pecially before a hunt.

All Mbuti men and women except the very old and the ry young help in the hunt. I'll tell about one I went on.

The band went singly or in small groups to an area that had been decided on the night before. Each of the married men and some of the older bachelors carried nets four feet high and between 100 and 300 feet long *(see photo)*. While the women and children went off into the forest, the men attached their nets together, forming a single net several thousand feet long. They hung the net on bushes and

(Continued on the next page)

This Mbuti hunter will tie his net to other hunters' nets to make a giant trap for animals. Nets are made of dried vines that the Mbuti shred and weave together. An Mbuti mother will often make a complete net to give to her son when he marries.

Scars on the author's head, hands, and body were made by Mbuti friends to show that he is a "son of the forest." They cut his flesh, then rubbed in plant ashes. Mr. Turnbull is Associate Curator of African Ethnology at The American Museum of Natural History in New York City.

Why Sing Before a Hunt? (continued)

low branches until it formed a large semicircle, with the hunters on the outside. Then they waited. The forest became very quiet. Not even crickets could be heard. Suddenly in the forest shouting and clapping burst out as women and children started to beat the underbrush.

They were about a half mile away, moving toward the net. An antelope bounded out of the bushes and ran toward the net where I was, but before it reached the net it turned away. Soon there was a sound of thrashing, and I knew the antelope had been caught in another part of the net. Several pygmies near me jumped over the net and ran in that direction to help in the kill.

Now came the most dangerous part of the hunt. When animals get caught in the net, they fight. The pygmies spear them or shoot them with an arrow that is tipped with a poison that can kill an animal in less than a minute. Everyone must know what his neighbors are doing, and each person must do what is expected of him. Otherwise the hunt may not catch enough food, or someone may be hurt or killed.

A small but dangerous antelope called a *sindula* got caught in the net near where I was. A 13-year-old boy speared it to the ground, but it kept thrashing and kicking about. Another youth ran over and speared it through the neck, and a third speared it through the heart and killed it.

After the hunt, the meat of any animals too large to carry back was divided up on the spot. The smaller animals were thrown into baskets carried by the women. Certain parts of the animals would later be given to children and to old people making sure that nobody went hungry.

How Is Singing Like a Hunt?

Maybe you can guess from my descriptions some ways that I think the pygmies' singing and hunting are alike, and why the hunting songs are always sung in hoquet, the most difficult form to sing.

For a song sung in hoquet to be "pleasing to the forest," all the singers must know their parts perfectly and sing them at exactly the right time. And if a pygmy band's hunt is to be successful, with no one getting hurt, the whole band must work together with perfect timing and knowledge of what the others are doing. A hunt has no leader, just as a song has none, but for either to be a success, everyone must work together.

I wondered why there is so much likeness between these two different and important parts of pygmy life. Does singing help teach a pygmy child the importance of working well with the other members of the band, long before he goes on his first hunt?

Sounds are important to the Mbuti in many other ways. "Noise" or "bad sound" is disliked because it does not sound nice and "displeases the forest," and also because it shows no cooperation with the rest of the band. It drowns out the forest's "talk"—animal cries and the sound of trees falling, for instance, which the pygmies need to hear in order to know what is going on around them.

You may say that if the Mbuti work so well together, why don't they all sing the same notes in a song? I think it's because the Mbuti are a very free people. They don't like to be bossed or made to stay in one place or do one thing. So in their singing, each person does something different, but the different things blend together to make one pleasing piece of music.

Some scientists at universities in the United States are studying Mbuti music very closely. Maybe they will be able to find ways to tell things about any society by listening to its music.

I hope some other scientists go to live with the Mbuti as I did. I paid a lot of attention to Mbuti music because I like music myself. Perhaps a scientist who likes wood carving, or painting, or weaving, or something else will find some important part of Mbuti life that I overlooked ■

xploring the Earthworm's World, Part 2

The first part of this series of articles told you how to collect some earthworms and keep them alive and healthy in a vivarium. Now, with some simple equipment from around the house, you can...

Teach a worm to Turn

by Marlene Robinson

■ If you have been taking good care of your earthworms in their vivarium, you can now try some investigations with them. You may wonder how a worm hears, tastes, and feels, since it has no eyes, ears, or tongue. For example, how did the worms find their food when you changed their feeding place?

An earthworm is sensitive to many things. It reacts to the moisture around it. It reacts to some textures beneath it, and to vibrations. It reacts to light and to chemicals.

To discover where a worm's sensitive areas are, chip a piece of ice so that you can use a small tip like a pointer. With the ice, touch a worm in various places like this: At the head end on the top side, then on the underside . . . in the middle along the top side, then on the underside . . . at the tail end on the top side, then on the underside. What part of the worm's body seems most sensitive? What part is least sensitive?

The area that is most sensitive will be the area where there are the most nerve branchings. Every segment has at least one pair of nerves, but the number of branchings differ *(see Diagram 1).*

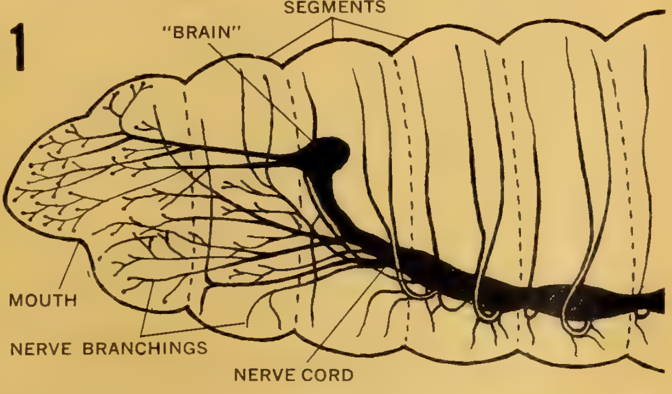
The cold ice causes some kind of pain and the nerve sends a message—"move"—to the muscles. Those segments that are touched move. But that is not all. The nerves connect with a main nerve cord that is a little like your own spinal cord. The message travels into and along this cord, both toward the brain and the tail end of the worm.

Every segment gets every message! Is it any wonder the whole worm turns? Sometimes it jack-knifes violently. Sometimes it just wriggles away. The longer you keep poking at the worm the more violent the reaction will become, even in the less sensitive areas. It is like making ripple waves in a pond with one pebble after another.

A worm in this condition is really a "bundle of nerves." It is exhausted. Put this worm into the cool, dark shelter of its vivarium to rest and work with another one for a while. Change worms each time you see these signs of exhaustion.

You might call this "over-reacting" and usually you will want to avoid it. In some of the investigations at the end of this article, however, you can use this to discover some fascinating things about the highly sensitive nervous system of the earthworm. *(Continued on the next page)*

1



This diagram shows the nervous system at the head end of an earthworm. A main nerve cord runs the length of the worm's body, with branchings of nerves in each segment.

A Worm Can Learn

In 1912 a scientist named Dr. R. M. Yerkes discovered that earthworms will eventually avoid a place where they get a mild electric shock. This clearly showed that earthworms can remember things. The worm can also change its actions according to what it remembers. This is called *learning.*

Dr. Yerkes developed a simple way of studying the learning process in worms. It is the T-maze, named for its shape. The worm crawls down the tunnel formed by the base of the T and has a choice of going either right or left at the arms of the T. One choice offered is "agreeable" to the worm; the other choice is not agreeable. Each time the worm goes through the maze and makes a choice, this is called one *trial.* Mr. Yerkes found it took quite a number of trials before a worm could remember which way to turn.

Later, Dr. L. Heck repeated the Yerkes experiment and found that many worms learned the path after 150 trials. One worm made only four "errors" in 120 trials.

Diagram 2 shows how to make a T-maze like those of Drs. Heck and Yerkes. You can use a simple maze to see how fast your worms learn by repeating the same experiment over and over. Remember to allow the worm to rest at least 10 to 15 minutes between trials.

Diagram 2 shows two different ways for making a T-maze. Model A is easier to put together, but Model B will last longer.

Use a plastic or pressed paper tray as a base for Model A. You will find this kind of tray beneath the meat that you can buy in a supermarket. Build the walls of the T out of modeling clay supported, if necessary, with toothpicks. The walls should be at least three inches high. Keep the insides of the walls smooth. Use clear plastic wrap over the whole thing as a "lid." Punch a few air holes in the plastic.

Model B can be constructed *inside* a clear plastic sweater box. These come with lids, and the walls should just barely touch the lid when it is in place. You can make the walls from strips of hard plastic or any smooth wood. Glue the walls into place.

All the walls in both models should be 12 inches long. The corridor along which the worm will crawl should be an inch wide. Label the openings A, B, and C *(see Diagram 2),* and keep notes on a worm's choices.

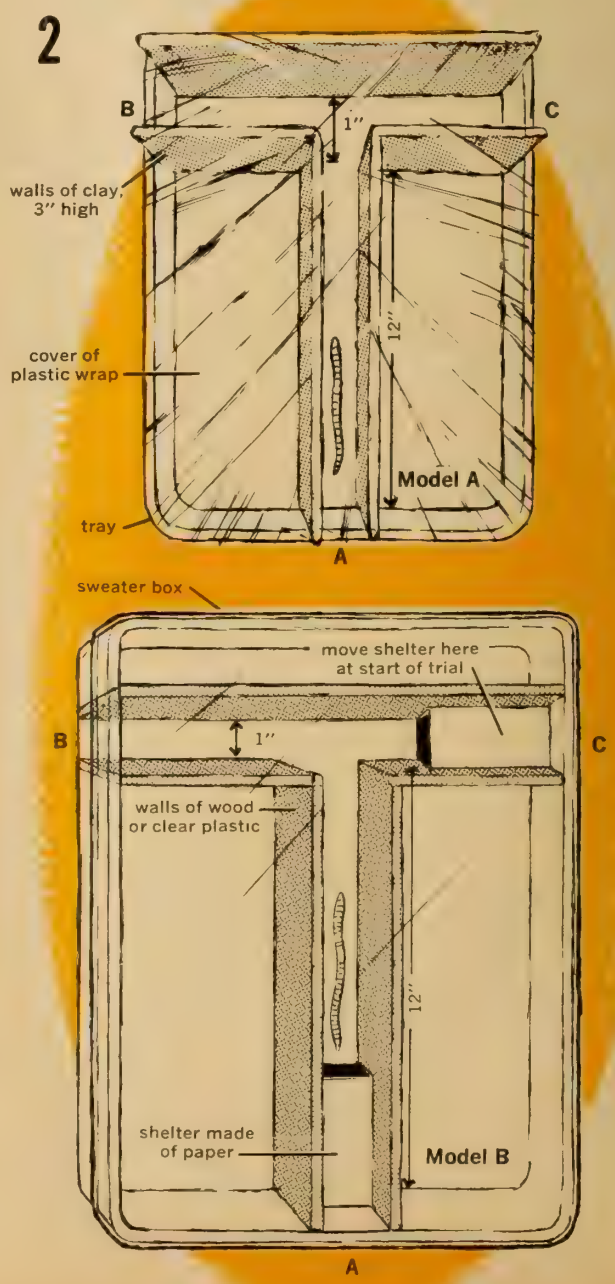
The arms of the T maze (B and C) will always be exits containing the worm's two "choices." The entrance to the maze is labeled A. The first four inches of A should be a dark shelter where the worm can rest before each trial. To make this shelter, fold an 8½-by-11-inch sheet of paper in half. Then fold this 5½-by-8½-inch paper in half again. Lay a one-inch wide ruler down the center. There will be something like a three-fourths of an inch margin on either side of the ruler. Fold these up against the ruler. Cut off the four inches needed, turn it over and set it inside the maze at A *(see Diagram 2).*

When you want to begin a trial, simply remove this little shelter and place it at C. The light will make the worm begin to move down the corridor. You can use a watch or clock with a second hand to time each trial. Begin timing as you lift the paper shelter and end timing when the worm has found the shelter again at C. Keep notes of the number of each trial and the time it takes.

Once your maze and shelter are finished, and you have a notebook, pencil, and watch ready, you can begin to find out how your earthworms learn ■

What goes on inside an earthworm's body? In the next issue of Nature and Science, *the author tells how to find out.*

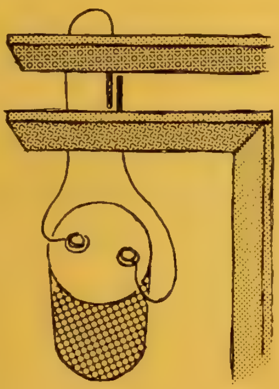
2



INVESTIGATIONS

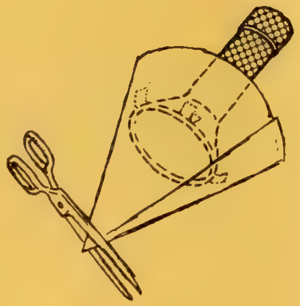
1. Put a worm beneath the shelter at A. Soak a 3-inch by 1-inch piece of blotter in vinegar mixed with water. Put the blotter at the exit end of B, then lift the shelter off the worm at A and put the shelter at C. Does the worm seem to "smell" the vinegar and react before actually touching the blotter? Does the worm react strongly to the vinegar and water solution?

Repeat this experiment using straight vinegar on another piece of blotter. Can the worm tell the difference between a mild acid and a stronger one? Repeat the experiment using a salt solution (1 ounce of salt to 3 ounces of water). You might also repeat the experiment by using "pine needle water" (mash up several ounces of pine needles in water; then soak a piece of blotter in this water).



2. Clear the insulation off the last inch of the wires attached to a dry cell (*see diagram*). Set these across the corridor at B. Then start a worm out at A and put the shelter at C, as before. When the worm crawls across both wires the circuit is completed and the worm gets a mild electric shock. This is something like the vibration of an alarm clock that can be used to bring worms to the surface of the soil (*see Part 1 of "Exploring the Earthworm's World," N&S, April 10, 1967*). Do your worms seem more sensitive to chemicals or to vibrations?

3. Just how sensitive is the earthworm's skin? You probably know the story about the princess who could feel a pea buried beneath a dozen mattresses. We would not quite expect the same of the earthworm, but do you suppose it can tell the difference between sandpaper and cotton? Put a 1-inch by 3-inch piece of sandpaper at exit B. Instead of the shelter, spread cotton along the end of exit C. On another trial, put sand at exit B and garden soil at exit C.



4. Make a cone with a circle of paper (*see diagram*). Fit the cone to your flashlight and tape it in place. Snip a small hole in the end of the cone. This narrows the beam of light so that you can shine it on a small part of the worm. Shine the beam of light on a worm when it reaches exit B. Aim at the head of the worm. Compare the reactions with those in investigations 1 and 2.

5. What temperature changes can a worm feel? Fill the end of exit B with crushed ice. Put the shelter at C. Will the worm crawl onto the ice at all? What happens if you block exit C and put the shelter beyond the ice at B? Will the worm crawl over the ice to get to the shelter?

The following investigations are a different kind. Do not use the "rest period" with the following.

6. Soak a worm in a glass of water for 20 minutes, then repeat Investigation 1. Does a nearly drowned worm react to chemicals as fast as a rested, normal one? Try drying out a worm by leaving it on the table top uncovered for 20 minutes and then repeat Investigation 1.

7. Expose a worm to bright light for 20 minutes. Do not let it dry out (keep it in a dish with a few drops of water). Then repeat Investigation 3. Does the worm exposed to bright light behave the same as a worm that rested in the dark shelter?

8. Chill a worm in the refrigerator for 10 minutes before repeating Investigation 5. Later wrap the worm in damp cotton and place it near a radiator where it can warm up. Then repeat Investigation 5. Does a worm move faster when it is warm or cold?

Do you find that the worms act the same in Investigations 6, 7, and 8 as they did in Investigations 1-5? Would you say that the way a worm acts has a lot to do with what has happened to it before a trial? Does this apply to humans too?

The Mechanics of a Bicycle

■ If you own a bicycle or have ever ridden one, you probably think of it as a rather simple device. But it took many years and the work of many people to design the bicycles we have today. Things that we take for granted, such as a bike's framework and the location of the seat, are important parts of a bicycle's design. They have changed a lot over the years *(see next article).*

Take a new look at your bicycle and the bikes of your friends. Using the illustrations and captions on these pages as a guide, you can get a better idea of how a bicycle works ■

The weight of a wagon rests on strong spokes of wood in the wagon's wheels. But a bicycle's wheels have only thin wire spokes. How do they support your weight? To find out, have someone sit on the bicycle seat, balancing the bicycle with his feet on the ground. Then find out which of the spokes are the tightest. Are the spokes that go down from the hub as tight as those that go up from the hub? (You can tell by plucking the spokes as you would a guitar string. The tightest ones make the highest pitched sound.) Does the weight of the rider seem to rest on the spokes under the hub? Or is it suspended on the spokes above the hub?

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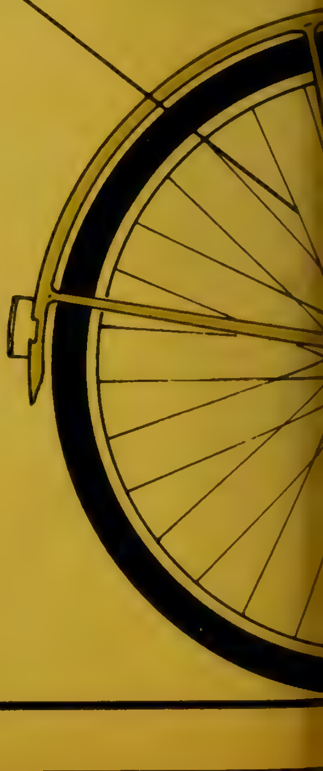

Find out how many teeth there are in the pedal sprocket of your bike. Then count the number of teeth in the rear wheel sprocket and divide this number into the first number. The number you get is called the *gear ratio.* For example, if the pedal sprocket has 48 teeth and the rear sprocket has 20, the gear ratio is 2.4. This means that the rear wheel turns 2.4 times for each turn of the pedals.

If your bike has gears, measure the distance the rear wheel travels during one turn of the pedals for each of the different gears. Does the "high" or "low" gear give you the greatest distance? Some bicycles have five different sizes of rear sprockets and two different pedal sprockets. Gears are changed by flipping the chain from one sprocket to another, giving the rider a choice of 10 different gear ratios.

Why is a fast-moving bicycle easy to balance while a slow-moving bike tips over easily? You can get an idea by comparing a bicycle with a coin. Balance a coin on its edge and then blow it over with your breath. Next roll the coin along a tabletop and try to blow it over again. The motion of the coin gives it a force called *momentum*. To knock the coin over you have to blow hard enough to overcome the force of momentum. A moving bicycle also has momentum, and momentum increases with speed.

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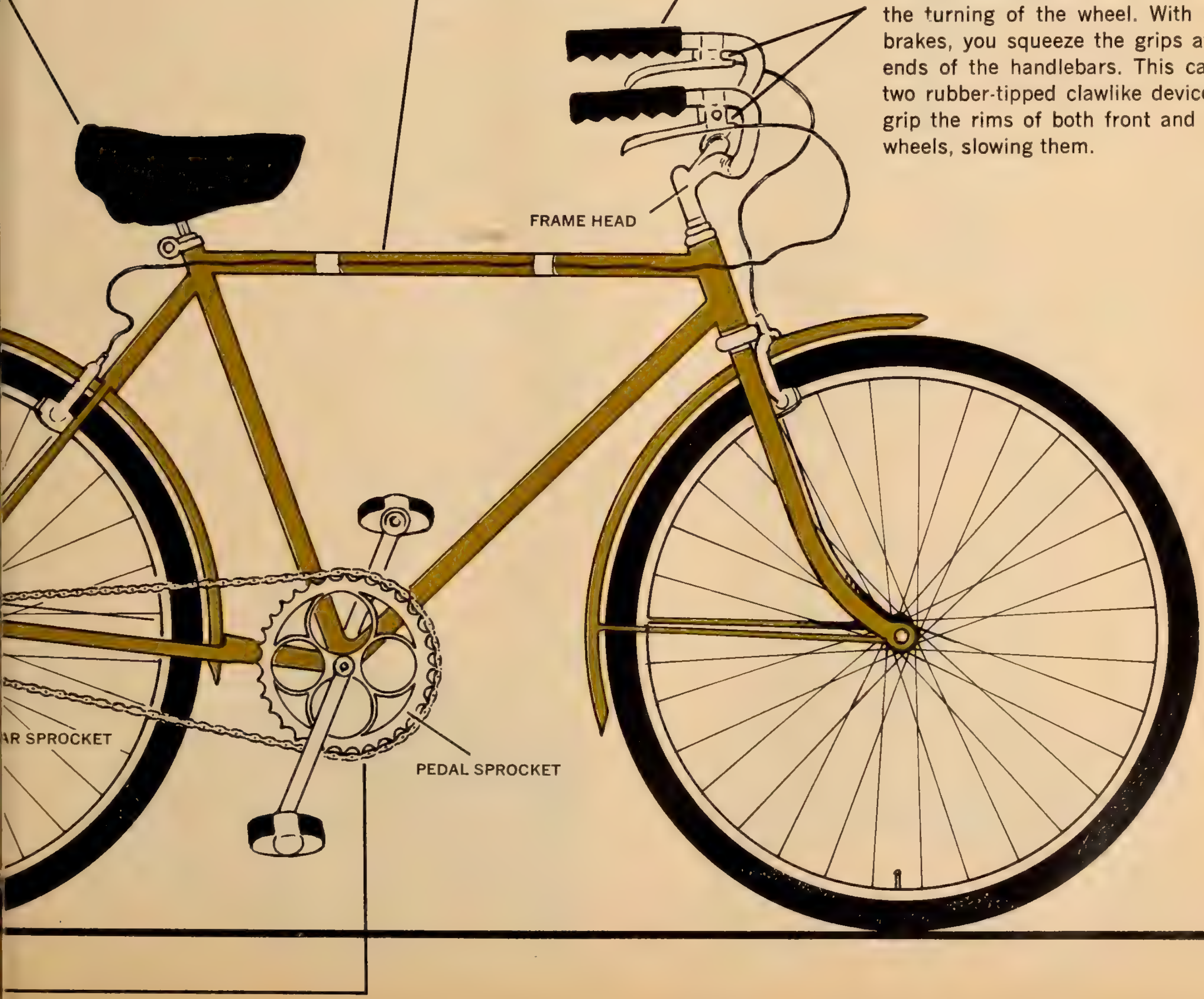
s affect steering?

You can probably lift your bicycle off the ground, yet its frame is strong enough to support the weight of several persons. What is there about the design of its framework that gives it strength? Can you find similar designs in bridges and other structures?

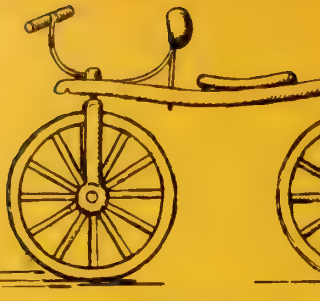
Try steering your bike with your hands close to the frame head. Then gradually move them out to the position where you can best control the bike. The handlebars act as *levers*, enabling you to steer the bike without great effort. Do you think it would be easier or harder to steer if the handlebars were even longer?

Bicycles have either of two kinds of brakes, American coaster brakes or English hand brakes. With coaster brakes, you push backward on the pedals, causing metal discs inside the rear wheel hub to press together. The friction produced by this contact slows the turning of the wheel. With hand brakes, you squeeze the grips at the ends of the handlebars. This causes two rubber-tipped clawlike devices to grip the rims of both front and back wheels, slowing them.



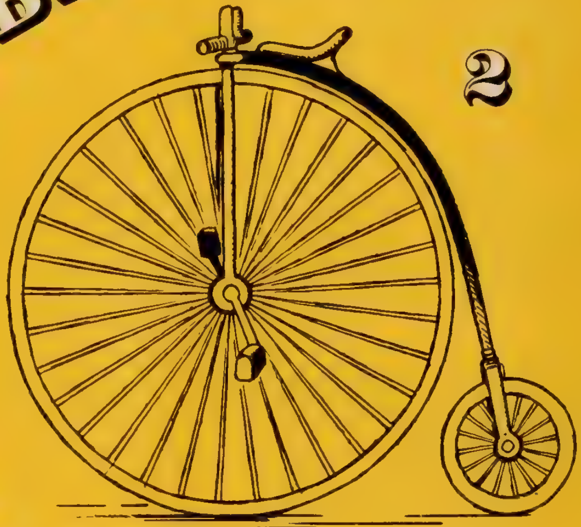
FROM "HOBBY HORSE" TO "HIGH RISE"

1



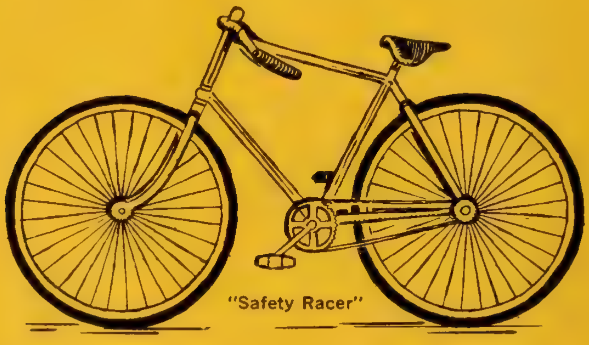
"Hobby Horse"

2



"Racing Ordinary"

3



"Safety Racer"

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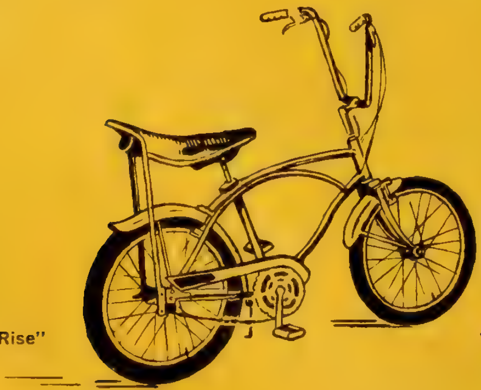


"High Rise"

■ The word "bicycle" means "two wheels," and two-wheeled vehicles with one wheel ahead of the other can be traced back a thousand years or more. About 150 years ago, in Europe, men began to experiment with two-wheeled vehicles of different designs. The bicycle of that time was called a *draisine, or* "hobby horse" (*see Diagram 1*). It had no pedals and was pushed along by the rider's feet.

Then, in 1835, a Scotsman named Kirkpatrick MacMillan put foot pedals on the front wheels of a "hobby horse." In order to make bikes travel faster, other inventors made bicycles with bigger and bigger front wheels. This enabled the rider to travel a greater distance with one turn of the pedals. Some of these bicycles, such as the "racing ordinary" (*see Diagram 2*), had front wheels five feet tall. They were speedy, but they also were hard to steer, hard to get on, and easy to fall from.

The inventor who freed man from this big-wheeled monster was H. J. Lawson of England. In 1876 he designed a bike with a chain that looped around a pedal sprocket and back around a similar sprocket on the rear wheel. As the pedals turned, the chain moved, turning the rear wheel. Lawson's invention was called the "safety" bicycle and it looked very much like the bikes of today (*see Diagram 3*).

Later inventions, such as gears and air-filled tires, helped make the bicycle an important means of transportation in many countries. The 30 million bikes in the United States, however, are ridden mostly for fun.

Part of this fun is provided by a bike of a new design (*see Diagram 4*) that has become popular in the past few years. This bike has small wheels and "high rise" handlebars. It is designed for quick starts, turns, and stops. The newest models have gear ratios that make this kind of bike more suited than before for long trips ■

In 1899, Charles M. Murphy rode his bicycle a mile in 58 seconds. He pedaled on boards behind a train that served as a wind shield. When the train slowed after the mile, Murphy's friends caught him as he crashed into the back of the train. The modern bicycle speed record is 128 miles an

HOW IT WORKS

Electric Meter

■ Whenever a light or other electrical device is switched on in your house, a glass-enclosed meter in your basement or on the outside of the house is recording how much electric current is being used. Every month or two, a man comes to "read" the meter, so that the power company can figure out how much electricity you have used and send you a bill. Here is how the meter works.

The electric current from the power company's wires flows through the meter on its way to and from the wires in your house. Inside the meter, the current passes through the coils of a small electric motor–something like the motor in an electric clock. The coils are made of wire wound around iron cores, and they are arranged so that the edge of a thin disk of aluminum can turn between the coils (*see diagram*).

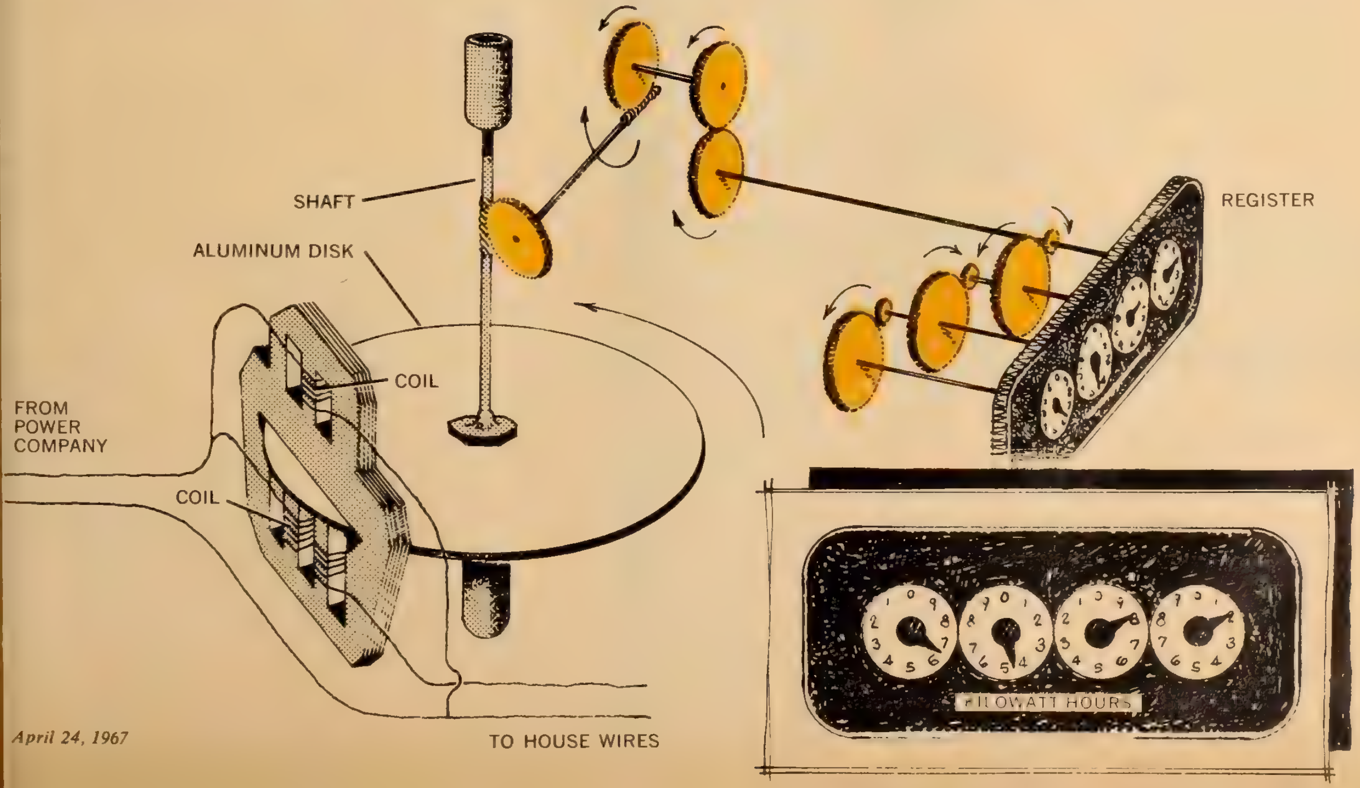
The current does not flow steadily in one direction through the coils, but *alternates,* or changes its direction, 60 times each second. Each time the current changes direction in the wire, the coils become *electromagnets* and give a magnetic "pull" that turns the aluminum disk. The more lights and other electrical appliances you are using, the more current is flowing through the coils. This makes the magnetic "pulls" stronger than before, so the disk turns faster.

The shaft of the turning disk is connected by gears and other shafts to the pointers on the *register* dials (*see diagram*). Each dial is numbered from 0 to 9, and the gears are arranged so that one complete turn of the pointer on one dial–from 0 around to 0–moves the pointer on the next dial to the left just one number, say from 0 to 1. (Notice that each dial is numbered in the opposite direction from the dial beside it.)

How Much Electric Power Do You Use?

Electric power is measured in *watts,* a unit named for James Watt, the Scotsman who invented the steam engine. A 100-watt light bulb draws 100 watts of electric power as long as it is switched on. If it is lighted for one hour, it uses 100 *watt-hours* of electric power. Because so much electric power is used today, the electric meter measures the power you use in *kilowatt-hours,* or 1,000-watt-hours.

To read the number of kilowatt hours your meter has recorded, read the dials from left to right—the number on each dial that the pointer has *just passed.* (The meter in the diagram reads 6,482 kilowatt-hours.) At the end of a month, read the meter again. Subtract the first reading from the second, and you will have the number of kilowatt-hours of electric power you and your family have used in that month.–FRED T. SUTTON, JR.



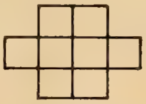
BRAIN-BOOSTERS

CAN YOU DO IT?

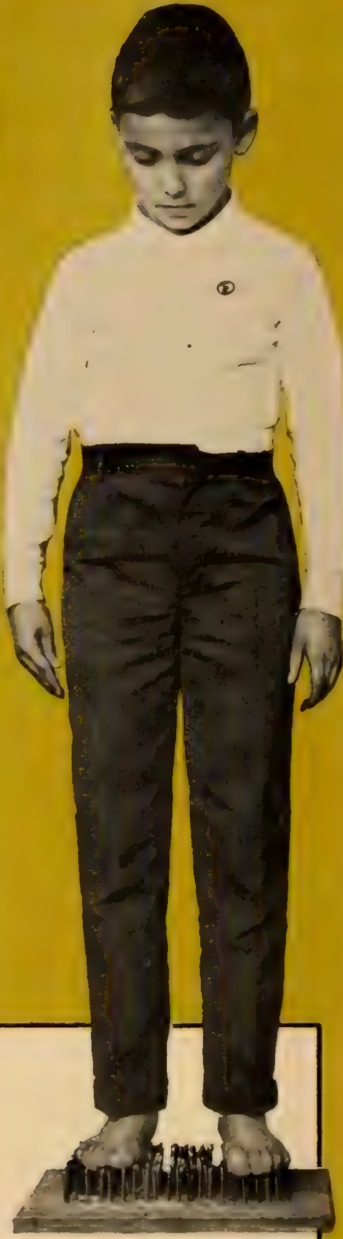
Can you tear a sheet of paper into a strip more than 20 feet long?

FUN WITH NUMBERS AND SHAPES

Fill in the squares of the diagram with the numbers from 1 to 8 so that two consecutive numbers (such as 2 and 3, or 6 and 7) are never in squares that touch each other—either at the sides or the corners.



Submitted by ?, in Marlboro, Mass. (Please send us your name.)

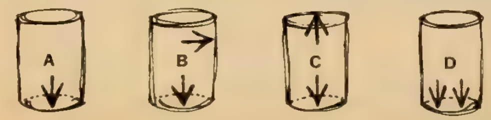


MYSTERY PHOTO

This boy is standing with bare feet on sharp nails. Why don't the nails cut his feet?

WHAT WILL HAPPEN IF...

...nail holes are punched in the cans of soda at the places marked with arrows? Out of which holes will soda flow?



FOR SCIENCE EXPERTS ONLY

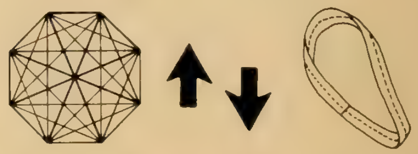
A king wanted to choose which of two princes could marry his daughter. He decided that there should be a horse race, and told the princes that the one whose horse ran *slower* would be the winner. Neither prince could understand how such a race would be possible. Finally, one prince had an idea of how the race could be run. He told the king his plan, and the king then let him marry his daughter. How did the smart prince suggest that the horse race be run?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

What will happen if? If soil is heated in an oven, it may change color as it dries out. The *organic matter* contained in most soils will burn and cause a strong odor. Is the soil the same after it cools off?

Mystery Photo: The tree grew in the unusual shape after it was almost blown down.

Can you do it? The figure has 28 lines. One way to count them is to redraw the figure.



Fun with numbers and shapes: A loop with a half twist is called a *Mobius Strip*. It has the strange property of having only one surface. Draw a pencil line along the loop and you will find that you can mark "both sides" of the strip without lifting your pencil. When a Mobius Strip is cut in half only one, larger loop is made. What will happen if you cut the larger loop in half again?

For science experts only: A man was to be shot if he made a true statement, and hanged if he said something false. To make it impossible for him to be either shot or hanged, he said, "I shall be hanged." This meant that he could not have been shot, since what he said would then have been false and he would have to be hanged. If he were hanged, however, what he said would have been a true statement, so he should have been shot.

THE SECRET LIVES OF WASPS AND BEES

by
ROBERT W. MATTHEWS
and
JANICE R. MATTHEWS

Biologists are still making new discoveries about the lives of these common insects. Here's how you can make some inexpensive "trap nests" and study bees and wasps in your own back yard.

■ "Ouch!"

Most of us at one time or another have become painfully aware of paper wasps, hornets, honey bees, and bumble bees. These are the *social* wasps and bees—well known for their stings and for the complex societies in which they live. But the social bees and wasps make up only a small part of all the kinds of bees and wasps. Their relatives, the *solitary* bees and wasps, make up about 98 per cent of all the kinds of bees and wasps in the world!

You may already know some of the common kinds of solitary bees and wasps. They include the mud-dauber wasps, potter wasps, sand wasps, mason wasps, sweat bees, leaf-cutter bees, and carpenter bees. Some, like the sand wasps, build their nests in the soil. Others, like the potter wasps and mud-daubers, make nests of mud. Still others make their homes in hollow twigs and stems. This last type, called *twig-nesters,* are among the easiest to observe.

You can easily attract the solitary bees and wasps to your back yard or window sill by providing homemade nest holes called *trap nests*. Trap nest homes are easily made by drilling holes of various sizes into pieces of soft wood. Scientists use these artificial hollow twigs to study the nests and habits of the solitary bees and wasps. (The investigation at the end of this article tells how you can do the same thing.)

The Lives of Twig-Nesters

Just as different kinds of birds can be identified by their nests, you can tell the different kinds of twig-nesters by the building materials and food supply in their nests. For example, the leaf-cutter bee uses circular pieces of leaves stacked several deep to make the walls between the cells where its eggs are laid. It uses long rectangular pieces to line the sides of each cell, completely hiding the pollen it has put inside. Other bees use a kind of leaf pulp, which they chew and then mold to form walls between the cells. Still others, the resin bees, use gummy plant sap as their main construction material. The yellow-faced bee lines every cell with a delicate cellophane-like material secreted from glands in its head.

Most of the twig-nesting wasps use mud as their chief building material. But some make their walls of loose piles of pebbles and others use plant sap much as the resin bees do. And one wasp that nests in hollow twigs uses grass as its main building material. It is an unforgettable sight to see one of these wasps flying through the air with a grass blade several times its body length trailing gracefully behind.

You can always tell the nests of bees from those of wasps by the kind of food stored inside for the young to

(Continued on the next page)

Robert W. Matthews is a graduate student in the Department of Biology, Harvard University, Cambridge, Massachusetts; his wife, Janice R. Matthews, is a research assistant at Harvard's Museum of Comparative Zoology.

Photo 1 shows a cell from the nest of a resin bee. The small larva *(see arrow)* is feeding on a mass of pollen or "bee bread." The dark cell wall to the right of the larva is made of plant sap (resin). Photo 2 shows some cells of the nest of a spider-hunting wasp. A small larva *(see arrow)* is feeding in the center cell, which contained 20 paralyzed spiders.

The Secret Lives of Wasps and Bees (continued)

eat. Bee nests always contain yellowish masses of pollen mixed with honey, called "bee bread" *(see photo).* Wasps always stock their cells with paralyzed animal prey, usually other insects. In fact, the main reason wasps have stings is not to defend themselves or their nests, but to paralyze prey. The poison injected by the sting rarely kills the prey but only keeps it from moving. This insures that the young wasp in its cell will have fresh meat to eat.

Caterpillars are probably the most common prey of wasps. But some wasps prey on spiders, packing from seven to 20 into each cell *(see photo).*

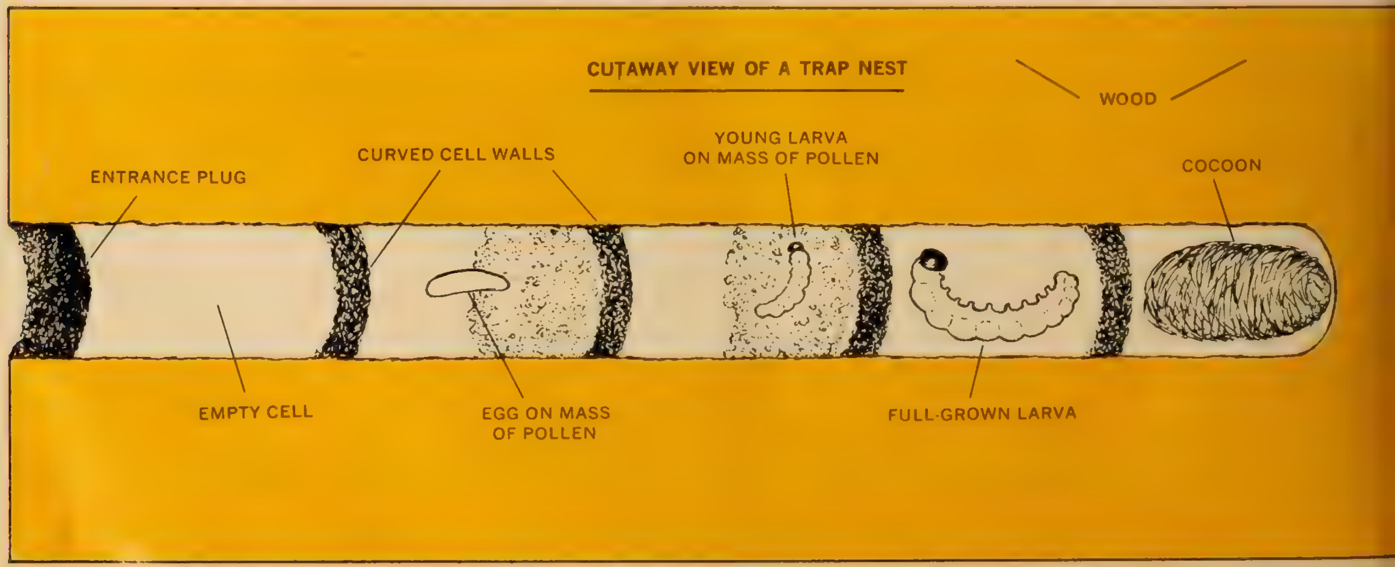
Life Inside the Cell

When filled, each nest is a lengthwise chain of cells (*see diagram*). These are begun from the bottom of the nest hole. Each cell is separated from the next by a thin wall made by the female. Each sealed cell is thus a closed room, containing a single egg and the food brought by the female. After the female has filled the hole with such cells, she flies away, never to return.

In a few days a small whitish *larva* hatches from the egg. It immediately begins to eat the stored food. The larva feeds for a week to a month, shedding its skin several times as it grows. After the larva finishes its food supply, it spins a cocoon about itself and changes into a *pupa.* Eventually a new adult emerges, chewing its way through the cocoon and the wall of its cell to freedom.

Most wasp cocoons spun in early summer produce adults about three weeks later. But in those spun after July, the adults usually do not come out until the following summer. Bee cocoons, however, rarely produce adults before the following spring or summer, regardless of when they are spun. One of the reasons for this is that bees often

(Continued on page 16)



INVESTIGATION

You can investigate the life history of the solitary bees and wasps in your back yard. They readily nest in artificial trap nests which are easy and cheap to make.

You will need to make about 25 to 30 trap nests. They are usually about 6 inches long by ¾ inch wide and ¾ inch thick, but you can change this to fit the wood you have. However, the grain must always run the length of each nest stick so that it will be easy to split open later. Knot free, seasoned white pine is the best wood to use.

When the individual nests are cut to size, bore a hole in an end of each one. If possible make holes of different sizes in different pieces of wood. This will provide nests for all sizes of bees and wasps. The best hole sizes to use are in the range of 3⁄16 to ½ inch. The depth of the holes is not critical, but you should use the longest drill bits you have.

Another way to make trap nests is to cut or gouge slots along the surface of your pieces of wood. For this you need tools such as a router or dado saw. Then cover each slot with another piece of wood. The two pieces can be tied, or held together with rubber bands. This method produces square holes, but they work just as well as round ones. These nests are much easier to open than those with drilled holes.

Watching Your Trap Nests

You can use the square hole method another way by tightly wrapping each nest with plastic wrap before covering the hole with another piece of wood. Staple or glue the plastic wrap in position. Then hold the entire nest together as before, with string, wire, or rubber bands. With this type of nest, the top piece can be lifted off while the bee or wasp is working inside the nest and you can see what it does inside. Also, by using this method you will be able to follow the entire development of the larvae with little disturbance to the nest.

Once your trap nests are made, put them outside near your house, either singly or in bundles wired or tied together. The trap nests should lay or hang on their sides *(see photos)*. Never put them directly on the ground. Put the nests in a variety of places—in trees, on window sills, stairways, along fences, in the shade and in the sun. In this way you will attract a variety of bees and wasps.

Each nest should have a permanent identifying number or mark. A felt marking pen works well for this. Keep a notebook of your observations. Make a record of the nest number, its location, and the dates on which the nest was being used. Leave space for other comments and observations. Keeping careful and complete records is an important part of any scientific investigation.

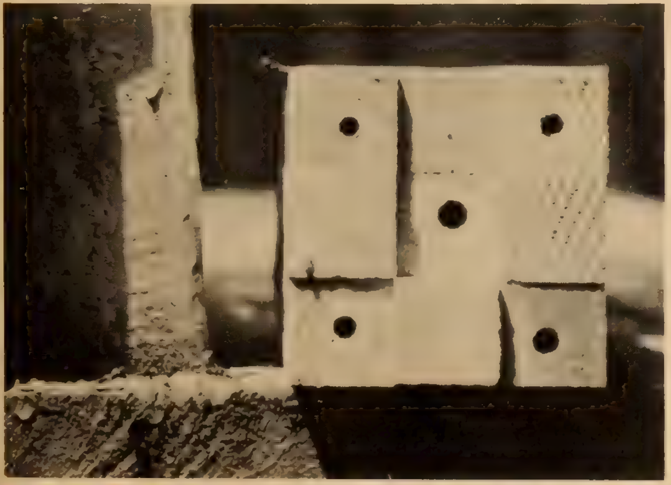
Watch your nests as often as you can. When you find one in use, watch to see how long the female is gone, what she carries when she returns, and how she carries it. What happens if you temporarily block the nest entrance? What happens if you change the position of the nest slightly while the female is gone? Perhaps you can think of some experiments to test what clues the female uses to find her way back.

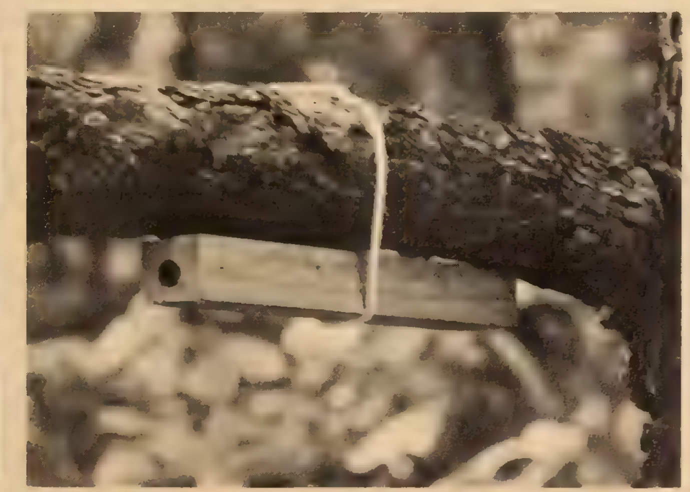
When a nest has been finished (with the entrance hole plugged with mud), take the nest inside and open it. If you use the round hole nests, you will need to split them open with a knife. Use a gentle prying action and *be careful not to dump the contents or crush the eggs or larvae.* They will *not* survive careless handling.

If you want to see the eggs and larvae, open the nests as soon as possible after the nest is finished by the female. If you delay a week or more, the larvae will probably have spun their cocoons.

Try to find the egg or young larva in each cell. A magnifying glass will be helpful. If you have a wasp's nest, carefully remove all the prey from one or two cells and count them. Keep a record of this. Now try to pack them all back in the cell again! See how long it takes the larva in the cell to eat all the stored food. When it has finished, you may want to see how much *more* food the larva will eat before spinning a cocoon. Find caterpillars, spiders, or whatever was originally in the nest and feed them to the larva yourself.

Do not let the nests get too dry. When not looking inside, carefully replace the split half and, holding it in place with rubber bands, keep each nest in a container such as a mason jar or plastic bag. This also keeps the new adults from escaping inside your home when they emerge.





will use only one kind of pollen as food in the cell. So they can only make their nests when that kind of pollen is available—when a certain kind of flower is blooming.

Which Way Is Out?

Some special problems await the new adults as they leave the nest. Most important, how do they tell which way is out? Deep inside a hollow twig, they cannot see the doorway. The wrong way leads to the bottom of the hollow, where they would die before they could chew their way out. Usually they are too big to turn around inside. Even in those cases where they can turn around, many species do not seem to try the "wrong" way. If an individual did choose the wrong way, it would probably destroy or block the occupants of the other cells in its path. Thus, knowing "which way is out" is vital for the survival of twig-nesters.

Fortunately, the new adults do not have to decide which way is out. They always come from their cocoons facing the right direction. But what tells the larvae to spin their cocoons so that the adults emerge facing out? How does the larva know which way to face? Dr. Kenneth W. Cooper of the Dartmouth Medical School, in Hanover, New Hampshire, has investigated these questions for many years. His work is a good example of the sort of studies that can be done with trap nests. The star of his story is a black pale-banded mason wasp named *Ancistrocerus* (An-sis-tro-*ser*-us).

Looking at the nests of these wasps, Dr. Cooper noticed that the mud walls between the cells looked different on the front and back sides. This was because the walls were made from the outside by the female as she was leaving each cell. She was thus able to smooth the outside surface, but the inner side remained rather bumpy. Also, the walls were not flat, but tended to bulge toward the back of the nest, away from the "door " *(see Diagram 1)*. Perhaps, reasoned Dr. Cooper, something in these cell walls "told" all the larvae to spin their cocoons facing out.

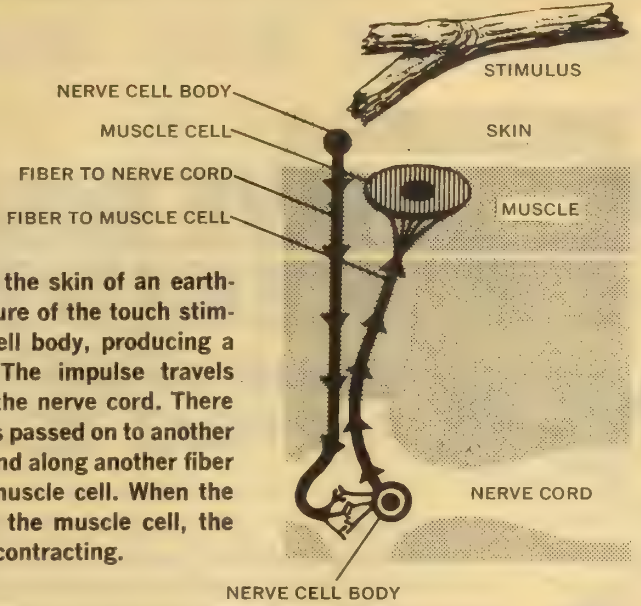
Dr. Cooper's first experiment was simply to turn the walls around in 27 cells—before the larvae were ready to spin. Twenty-four of these were "fooled" into facing their cocoons the wrong way! Dr. Cooper wondered: Did one or both walls of the cell provide the clues? Were the larvae noticing the texture of the wall or the way it curved, or both?

To answer these questions, he made artificial walls, using discs of cardboard for smooth flat walls, and the ends of gelatin pill-capsules for smooth curving walls. Then he also roughened some of both kinds of walls with sandpaper to make them bumpy. Using these artificial cell walls in different combinations, Dr. Cooper watched the way the pupae faced in each cell.

The authors, Janice and Robert Matthews, are shown here putting a split-open trap nest under a low-power microscope so that they can observe the developing wasp larvae.

From this series of experiments, Dr. Cooper discovered that the larvae were noticing both the way the walls curved *and* their smoothness or roughness. However, either wall alone was usually enough to allow them to face out correctly, even if the single wall were only curved *or* textured. Thus, the female wasp had left the larvae more clues than they actually needed, so there was little chance for a mistake. In fact, Dr. Cooper was able to show that completely unrelated wasps, as well as *Ancistrocerus*, were able to find their way from their nests by the clues in the cell walls. Apparently all the twig-nesting mason wasps "speak the same language"! ■

■ An advanced book that tells how biologists have learned about twig-nesters and other wasps is **Wasp Farm**, by Howard E. Evans, The Natural History Press, Garden City, N.Y., 1963, $3.95.



When you touch the skin of an earthworm, the pressure of the touch stimulates a nerve cell body, producing a nerve impulse. The impulse travels along a fiber to the nerve cord. There the "message" is passed on to another nerve cell body and along another fiber that leads to a muscle cell. When the impulse reaches the muscle cell, the cell responds by contracting.

Using This Issue . . .
(continued from page 2T)

Activity

To show how conditioning occurs, try this demonstration in your classroom. Without alerting your pupils that the activity has anything to do with conditioning, ask them to make a tally mark of some kind on a piece of paper each time you say "write." Stand at the rear of the room. Each time you say "write" (about two times a second) also tap a ruler on a desk or on the wall. The students will associate both stimuli (the word and the tapping sound) with their response (making the mark on paper).

After saying "write" at least 20 times, stop using this stimulus but continue rapping with the ruler at the same pace. Many students will continue to make marks. They have been temporarily conditioned.

Secret Lives of Wasps and Bees

The stings of social wasps are not to be taken lightly, but the solitary wasps and bees described in this article are another matter. They rarely make any effort to defend their nest and most of them can be handled gently without causing them to sting. Howard Ensign Evans, author of the fascinating book *Wasp Farm*, writes, "I would rather be stung a hundred times by digger wasps than once by that darling of the philosophers, the honeybee!"

The great diversity in ways of reproduction was stressed in the March 27, 1967 issue of *N&S*. This diversity is illustrated once more in this article, as the authors tell about some of the varied ways in which bees and wasps go about reproducing young. The most obvious differences between many of these insects is in the construction or locations of their nests, and the kind of food that is provided for the developing young.

The importance of reproduction in the lives of animals is exemplified again by the life span of the adult female wasp; nearly all of her two-to-four weeks of life are spent building nests, stocking them with food, and laying eggs. Then she dies.

The trap nests should be checked regularly, preferably daily. You can tell if a nest has been started by peering down the bore, with the sun behind you. A completed nest will have a plug of mud or other material at the entrance of the bore.

Activities

- If you discover a nest under construction, sit nearby and keep notes on your observations. Time several trips to find out how long it takes a wasp to catch its prey or a bee to gather a load of pollen. (In their observations, the authors found a range of from 30 seconds to 15 minutes.) How does the wasp hold its prey? How long does the insect spend in its nest? Does it spend the night inside?
- Try to find natural nests in hollow twigs and make a display of them. Bees and wasps often nest in raspberry, sumac, elderberry, and other plants with soft pith.

Physical Science Books . . .
(continued from page 1T)

children. Curiously, the presentation of the prolific Mr. Moore merely lists "new words." The two photographs he uses of our side of the moon are both incorrectly printed, showing side-to-side reversal.

Salt, by Augusta Goldin (Thomas Y. Crowell Co., 35 pp. $2.95) is a delightful book for the youngest of readers. Directly and simply, Mrs. Goldin presents the basic story of salt—properties, occurrence, processing—and she also involves the reader in the story by suggesting activities that relate to the child and his experience. The illustrations not only decorate but also blend expertly with the text.

Weather All Around, by Tillie S. Pine and Joseph Levine (McGraw-Hill Book Co., 48 pp., $2.50) can serve well as an introduction to the study of weather for the very young reader. It identifies the elements of weather and the instruments used in their measurement. The child's own experience is used to develop ideas and activities. The pronunciation of more difficult meteorological terms is indicated in the text.

The Wind, by Jeanne Bendick (Rand McNally & Co., 80 pp., $2.95). For the intermediate elementary grade level child, this book simply and clearly tells the story of wind. Legend and fact are both identified in highly readable fashion. The relationship of wind to weather is accurately discussed and illustrated, but it is a book about wind, not weather. A thorough index makes it useful as a reference work on the subject.

Science Teasers, by Rose Wyler and Eva-Lee Baird (Harper & Row, 106 pp., $2.95). Puzzles and problems, and the tricks of magicians, all seemingly flaunting physical laws, are presented to the inquisitive reader for his explanation. The physics of the situation is then presented. It should be intriguing to the more imaginative pupils at the intermediate and upper elementary levels.

Motion, by E. G. Valens (The World Publishing Co., 80 pp., $3.50) is an interesting departure from the

(Continued on page 4T)

Physical Science Books . . .

(continued from page 3T)

usual science presentation in that photographs are used exclusively to illustrate the text. Most of them were specifically prepared for this book. Many of them are multiple exposures. But they leave the feeling that good drawings would present the information more effectively with no fundamental loss in realism. The text, for intermediate elementary grade levels, builds up to Newton's Laws adequately.

Basic Inventions, by Irving Robbin (Grosset and Dunlap, 48 pp., $1) is a part of the "How and Why Wonder Book" series. This should be a fascinating source of material for intermediate or upper elementary grade children working on special projects, or just wondering how things might have started. Tools, fire, agriculture, wheel, gunpowder, printing, and optics are explored for their beginnings. The history of great modern developments is summarized.

Push and Pull, by Paul E. Blackwood (revised edition, McGraw-Hill Book Co., 192 pp., $3.95) is the story of energy—all types of energy, neatly arranged so that the material can be covered in small doses. Experiments are integrated with the easily-read text. Glossary and index add to its usefulness for intermediate elementary grade levels.

Water Fit To Use, by Carl Walter Carlson and Bernice Wells Carlson (The John Day Co., 128 pp., $3.86) is a timely volume dealing with a significant problem. Provocative photographs add to its impact. It should be especially useful in leading to projects in water pollution and control, both in science and social studies courses.

Weather or Not, by Florence W. van Straten (Dodd, Mead & Co., 237 pp., $5) is a presentation of weather and its control by reminiscence. Sometimes fascinating, sometimes rambling, this book is always hard to put down. There is nothing shy about the author, and her reactions as a professional meteorologist to some of the ideas of modern meteorology are just not found in textbooks. Few are capable of putting as much zest into their subject as she does. An index adds to the book's usefulness.

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nature and science

TEACHER'S EDITION

VOL. 4 NO. 16 / MAY 8, 1967 / SECTION 1 OF TWO SECTIONS

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(FOR YOUR CLASSROOM BULLETIN BOARD)

Things You Can Do This Summer

Summer vacation will give you time and good weather for exploring, investigating, and making some of the things *Nature and Science* has described during the school year. Why not try some of them? Look in back issues to refresh your mind on how to—

Study the nesting ways of bees and wasps that live alone *(April 24, 1967).*

Experiment with pollen and spores to learn about reproduction in ferns and flowering plants *(March 27, 1967).*

Make a sea aquarium and collect animals to live in it *(Oct. 31, 1966).*

Measure the number and size of raindrops at different times in a storm *(Oct. 31, 1966).*

Build a home for earthworms and study how they live and learn and the structure of their bodies *(April 10, 24, May 8, 1967).*

Dye cloth with colors you get from bark, nuts, onions, flowers, and other plant parts *(Oct. 3, 1966).*

Grow plants without seeds by cutting parts off old plants and planting them *(Dec. 19, 1966).*

Find out how fast plant cells take in water and lose it *(Jan. 30, 1967).*

Test paper for tensile and compression strength *(Feb. 27, 1967).*

See what happens to seeds that are planted too early in the year *(April 10, 1967).*

Estimate the number of sand grains on a beach or the number of beans in a bottle *(Sept. 19, 1966).*

Determine what makes a ball bouncier *(March 13, 1967).*

Observe guppies to see how they reproduce *(March 27, 1967).*

Investigate the acids and bases in household substances *(Feb. 27, 1967).*

Be a fingerprint detective *(Nov. 14, 1966).*

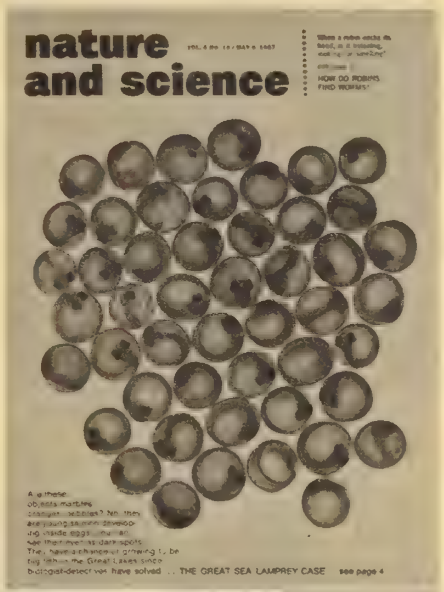
Flip pennies to see which comes up most often, tails or heads—and why *(Nov. 14, 1966).*

Make and change sound waves *(Oct. 17, 1966).*

Discover patterns in nature that most people never see *(Dec. 5, 1966, May 8, 1967).*

Find out which materials produce the most friction, and what changes its force *(Dec. 19, 1966).*

Find out: how much air you breathe *(April 10, 1967);* whether the average height of wildflowers is different in summer months *(May 8, 1967);* which metals hold more heat *(Feb. 13, 1967);* how your eyes help you keep your balance *(March 13, 1967);* how much heat is needed to melt ice *(Jan. 30, 1967);* which materials are good heat insulators *(Dec. 5, 1966);* how to speed up chemical reactions *(May 8, 1967).*



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

How Do Robins Find Worms?
A biologist set out to discover whether robins find worms by sight, sound, smell, or vibrations.

● **The Great Sea Lamprey Case**
By studying the lives of sea lampreys, then finding a lamprey poison, biologists are beginning to control this animal that has killed many of the fish in the Great Lakes.

● **How Nature Does the Twist**
This WALL CHART may start your pupils looking for spirals in nature.

● **Inside an Earthworm**
By dissecting a worm, your pupils can discover how earthworms are adapted for their life in the soil.

Investigating Wildflowers
Your pupils can investigate the adaptations of different kinds of wildflowers in spring and summer.

Index to Nature and Science, Vol. 4

● **Speeding Up Your Reactions**
Simple tests with Alka-Seltzer and Bromo-Seltzer show your pupils some ways to speed up chemical reactions.

This is the last issue of *Nature and Science* for the current school year. You can reserve your subscriptions for next fall right now, and receive free a copy of *Crossroad Puzzlers*, a new book by David Webster, our "Mr. Brain-Booster." *(See page 4T.)*

We hope we will be able to serve you and your students again next fall.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

The Sea Lamprey Case

Lampreys are not fish, although they resemble eels. They are *agnaths,* jawless creatures without backbones. They do have a *notochord,* a flexible rod that supports the body.

Sea lampreys are usually thought of as parasites, but the term "predator" seems more appropriate for the lampreys that have wiped out many of the large, valuable fish of the Great Lakes. By greatly reducing the populations of big fish, the lampreys also limit their own numbers. Biologists believe that, if left alone, a balance would eventually be struck between the fish and lampreys. But this might take centuries.

Drastic increases or decreases in animal populations are the exception in nature, with a complex system of checks and balances usually maintaining an equilibrium. "Upsets" such as the fish-lamprey situation in the Great Lakes often begin when man unwittingly introduces an organism into a new environment. (Ask your class to find examples of other such "upsets.")

Topics for Class Discussion

- *Why are lampreys less destructive in Lake Erie than in the Great Lakes west of it?* Erie is the shallowest and warmest of the Great Lakes and is not an ideal habitat for sea lampreys. Lake Erie's shallowness and warmth are also contributing factors in its slow death by pollution.

- *How would you go about finding a way to control a destructive animal like the lamprey?* Dr. Applegate first studied the lamprey to learn as much as possible about its life. By doing this, he found a vulnerable point in the animal's life cycle: the breeding of the lampreys in tributary streams and the long stay of the young there. (If the entire lamprey life cycle were spent in the lakes, man would probably be powerless to control these animals.) By studying the lives of harmful animals, scientists can usually find some opportunity for control—for example, at some vulnerable time in the life cycle, by use of a natural enemy of the animal, or because of a way of behavior of the animal.

- *Help explode some science myths.* Through Science Adventure articles such as this one, and in other articles, *N&S* tries to show that science is an inquiry in which anyone can participate, not just the province of a few people who work in mysterious ways that no one else can understand.

In reading and discussing such articles, however, your students may lose one myth and gain another: that science is always easy and exciting. In this article, for example, the six-year search for a lamprey poison by Dr. Applegate and his associates is glossed over in a paragraph or two. To give your students a realistic picture of science and scientists, you might remind them that it did take six years of rather dull, routine work. Dr. Applegate himself described it as "six years of unmitigated boredom."

How Nature Does the Twist

Learning to recognize patterns that occur repeatedly in the world around us is more than just an exercise in aesthetics. In a sense, the whole process of education is one of learning to recognize patterns in objects, natural phenomena, behavior, ideas, and so on, and learning how to use or change such patterns for survival. Scientific research is basically the search for such patterns, for their causes, and for ways to use or change them.

Suggestions for Classroom Use

Have your pupils try to draw a spiral free-hand, without looking at one. Then have them look at the Wall Chart and see whether their spirals are more like the coiled rope diagram or the curve of the nautilus shell. Have them try to describe the difference between these two spiral shapes.

The coiled rope spiral is regular in shape, with each coil the same width as the others. It can be described as a long, thin cylinder coiled around itself.

In the nautilus shell, the coils get wider and wider as they spiral outward. It is as if a long, hollow cone were coiled around its peak. This shape is called a *geometrical spiral.* (An elephant's trunk, an octopus's arm, and a monkey's tail are shaped like long, thin cones; when coiled, they form geometrical spirals.)

Shells, horns, and other fixed animal structures often grow in a spiral form. Point out to your pupils that all parts of a hand, or foot, for example, grow, while only one end of a snail's shell or ram's horn grows, leaving the part that formed earlier unchanged. A large shell with many sections looks just like a small one with only a few sections, except that it is larger. Each new part that is formed is bigger around than the part formed just before it, giving the shell or horn a geometrical spiral shape.

The scales of a pine cone increase in number and width from the tip to the base of the cone, producing a spiral structure that you can follow with your finger from the base to the tip of the cone.

A whirlpool is fed water at one end only, from all sides, so that it widens out in a geometrical spiral. A tornado grows much the same way, with air and water vapor from all sides being fed in at the top end.

(Continued on page 3T)

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nature and science

VOL. 4 NO. 16 / MAY 8, 1967

When a robin cocks its head, is it listening, looking, or smelling?

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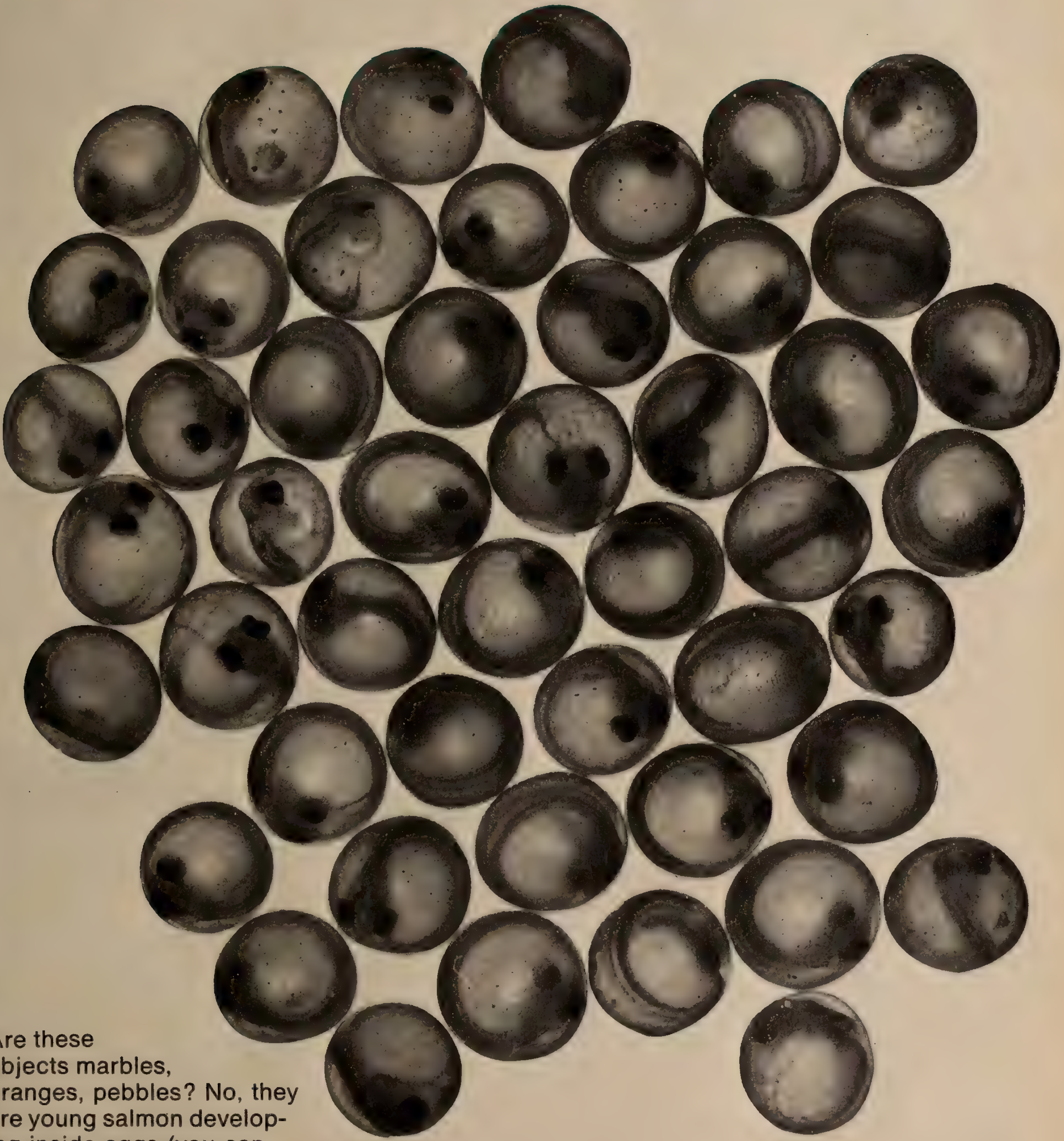
HOW DO ROBINS FIND WORMS?



Are these objects marbles, oranges, pebbles? No, they are young salmon developing inside eggs (you can see their eyes as dark spots). They have a chance of growing to be big fish in the Great Lakes since biologist-detectives have solved . . . THE GREAT SEA LAMPREY CASE

see page 4

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How do robins find worms?

by Laurence Pringle

When a robin cock
its head over th
ground, is it lookin
smelling, or listenin
for a worm

■ You've probably watched a robin search for worms on a lawn. It runs along, pauses, cocks its head, and then strikes with its bill. Often it brings up a wiggling worm.

As you watch a robin doing this, you may wonder: How does it find worms? Does it smell them? Does it listen for the faint movements of worms in their burrows? Or does a robin turn its head to spot the worms with its eyes?

A few years ago, many people believed that robins listen for worms, while most scientists who study birds *(ornithologists)* thought that robins find worms by sight. No one knew for sure until Mr. Frank Heppner (now a graduate student at the University of California, at Davis) set out to find the answer.

Mr. Heppner first did a lot of robin-watching, especially in the early morning and about sunset, when robins seem to find worms most often. One clue he noticed was that the robins had greater success getting worms where the grass was sparse than where it was thick.

Usually a robin would run along the ground for five to 15 feet, then stop. Next it would cock its head to one side for a few seconds. Then it cocked its head the other way, so that the opposite side of its head was pointing toward the same spot on the ground. The bird might cock its head back and forth this way several times. Then the robin would either straighten up and run off to a new spot, or jump forward, thrusting its bill into the soil to get a worm.

Mr. Heppner wondered if he could see worms by getting close to the ground like a robin. He found that he could spot worm holes when his eyes were six inches from the soil. And after a rain or when a lawn had been watered, he found that he could actually see the ends of worms a quarter inch or so inside the holes.

Listening to Worms

To test the idea that robins might find worms by their sounds, Mr. Heppner first had to find out if worms do make sounds. He used a sensitive sound recorder, putting a microphone two inches above the soil in a box where he let some earthworms go. The recording was made while the worms burrowed into the soil. It showed that the worms did make very faint sounds as they moved.

Mr. Heppner then made some recordings in the same way of the sounds on lawns and fields where robins were feeding. He found that the noise from a nearby powerhouse was much louder than the sounds that earthworms make. From this evidence he decided that, on many lawns, robins probably would not be able to hear the faint sounds of worms very well.

To check this idea further, Mr. Heppner set up a small lawn (five by nine feet) inside a cage. He watered and cut the lawn and kept it well-stocked with earthworms. By letting some captive robins hunt for worms on this lawn, he could see how successful the birds were in their search.

Then he set up a device in a corner of the lawn that produced "white noise"—a range of sounds that *masked*, or covered up, the sounds that worms make. He let some robins hunt for worms while the "white noise" was produced. Then he compared the success of these robins with other birds that had hunted for the same length of time without "white noise."

The "white noise" didn't seem to bother the robins at all. They caught just as many worms as the other robins. They even caught worms that were about a foot from the loud-speaker that was producing the noise.

By now it seemed clear that robins didn't find worms by detecting their sounds. Next Mr. Heppner did some experiments to see if robins might be able to locate worms by smelling them. He mixed some earthworms in a blender, then put this mixture in the food dishes where the captive robins usually ate minced apples, raisins, and baby food. He didn't feed the birds that day, making sure that they were hungry. But the birds paid no attention to the smelly "blended" earthworms.

What about Vibrations?

One other possibility remained: Robins might detect worms by feeling vibrations from the worm's movements in the soil. (But if a robin can feel such vibrations through its feet, why should it cock its head?) To test this idea, Mr. Heppner put a half-inch of soil in a shallow pan and made some imitation worm holes in it. He cut the tip ends from some worms and put these tips just inside the holes. Then he put the pan of soil on the lawn where the captive robins fed and watched to see if the robins could detect these "worms."

The birds had no trouble finding the worm tips in the pan, although they made a few mistakes, pecking at empty holes. Since the worm tips sent out no vibrations, the robins must have found them in some other way.

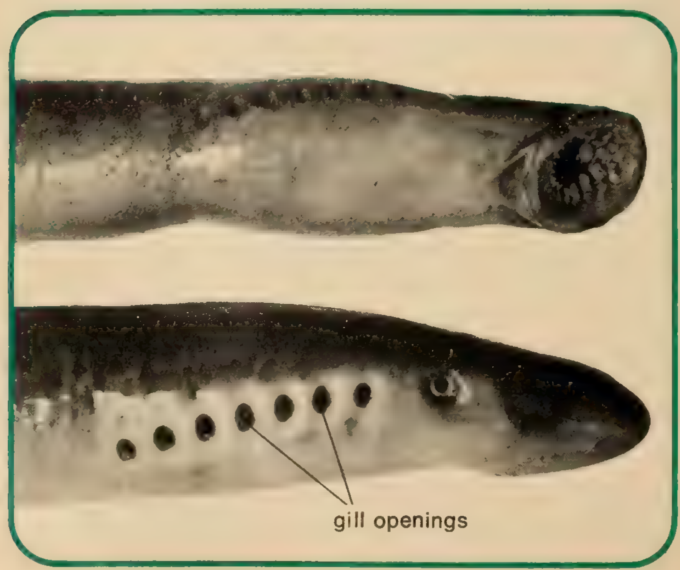
How do robins find worms? Hearing, smell, vibrations—each of these was eliminated by Mr. Heppner's experiments. He concluded that robins find worms with their keen eyesight. Since a robin's eyes are located on the sides of its head and its eyeballs cannot move much in their sockets, a robin must cock its head to give one eye a full view of an object on or in the soil. By cocking its head back and forth, the robin pinpoints its target and is ready to strike ■

A killer is loose in
the Great Lakes, attacking
big trout and
other valuable fish.
Here is the story of how
biologist-detectives have
tried to halt the killer.

The Great Sea Lamprey Case

by Russell McKee

A sea lamprey has a toothed tongue and 125 horny teeth that rasp a hole in the side of a fish. Then the teeth hold fast as the lamprey sucks blood from the fish. Liquids from glands in the lamprey's mouth keep the fish's blood from clotting.



■ One day in 1920, a fisherman was hauling in his nets in eastern Lake Erie. As he lifted one net, he found a strange creature stuck to a whitefish. The creature was gray, and about 18 inches long. It looked like a short piece of gray garden hose. When he pulled the animal from the fish he saw that it left a round wound on the fish. The strange animal had rows of sharp teeth that turned inward and a rough tongue, like a file *(see photos).*

Soon the fisherman found more of these eel-like animals. Then other fishermen reported the same trouble. Scientists said the animal was a *sea lamprey.*

You might ask: How can a *sea* lamprey live in the fresh water of Lake Erie? You might think it could live only in salty ocean water. Normally, that would be true. But Lake Ontario is close to Lake Erie *(see map).* Thousands of years ago, Lake Ontario was salty, like the ocean. Sea lampreys were in Lake Ontario at that time. As centuries passed, rain and melting ice washed the salt water down to the ocean. Some sea lampreys stayed in Lake Ontario, and they gradually adapted to the water as it grew fresher. Even though they were like ocean-living sea lampreys in most ways, they were able to live in fresh water.

However, they could not get past Niagara Falls into

Lake Erie. Then the Welland Canal was built to join the two lakes. Sea lampreys swam up the canal. In Lake Erie, the lamprey was a nuisance and killed many fish, but fishermen were able to keep working.

Like all plants and animals, the lamprey can only live well where it finds favorable living conditions. In Lake Erie, conditions were not ideal for the lamprey. Then it reached the next of the Great Lakes—Huron. In Lake Huron it found everything it needed—deep cold water and plenty of food. The food was many fine fish such as lake trout, whitefish, burbot, cisco, bass, and pike. These are all fish that people like to eat. Many men made their living by catching and selling those fish.

But now the lamprey had come, and soon the fishermen in southern Lake Huron caught fewer and fewer fish. Then fishermen in northern Lake Huron reported the same trouble. Soon lampreys passed the Straits of Mackinac *(see map)* and entered Lake Michigan and kept right on killing fish. Between 1940 and 1950, the catch of lake trout fell from 11 million pounds each year to less than one million pounds. By 1955, the total weight of all the lake trout caught in Lake Michigan and Lake Huron for one whole year was only a few hundred pounds.

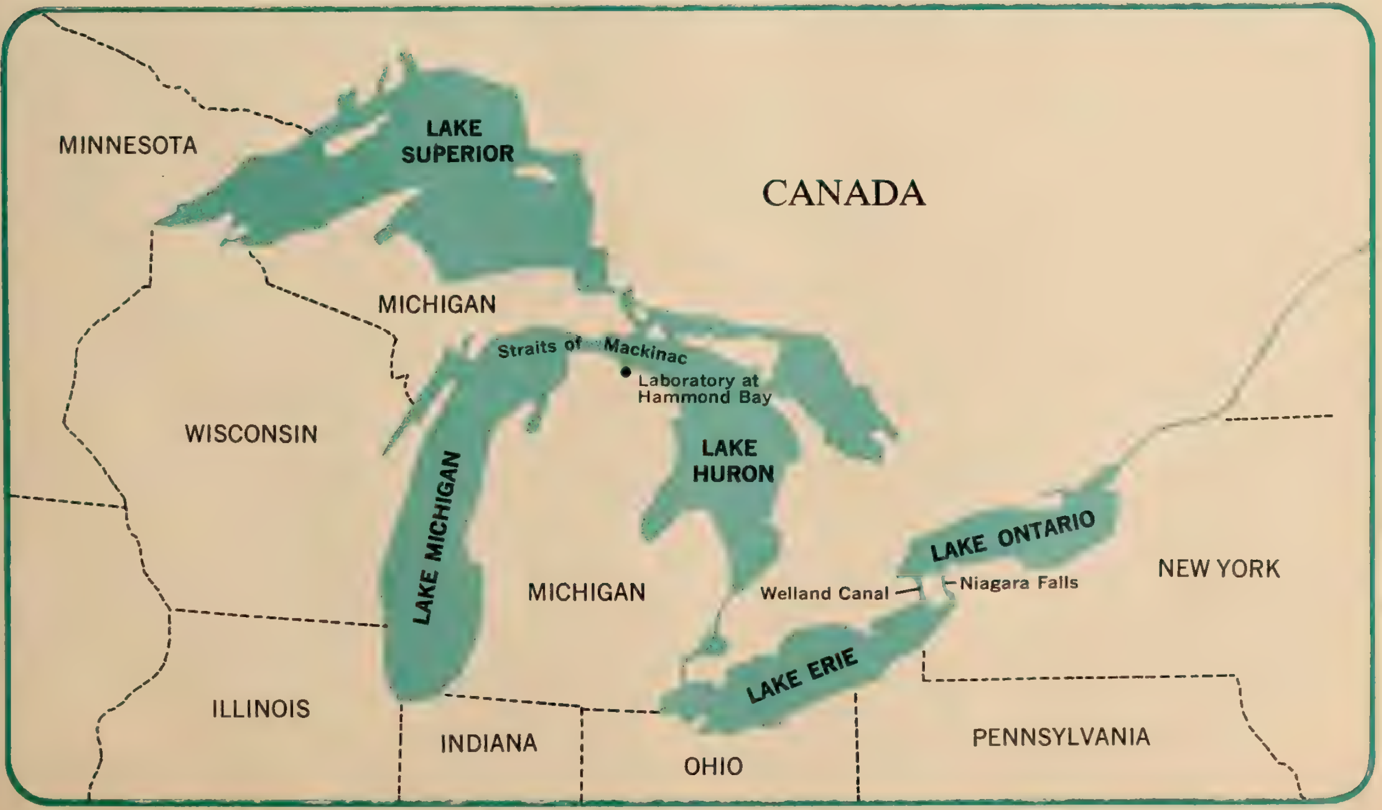
Before long, lampreys had reached Lake Superior and were killing fish there, too. It looked as though the lamprey would take over the lakes for good. Many fishermen simply tied their boats to docks and quit fishing. No one knew what to do. Fishermen and biologists held meetings and tried to find an answer. But no one even knew much about the lamprey.

Beginning in 1945, biologist Dr. Vernon Applegate began to study the lives of sea lampreys, trying to find a way of controlling these destructive animals.

Learning the Lamprey's Ways

In 1945, a biologist named Dr. Vernon C. Applegate *(see photo)* was asked to find out all he could about the lamprey. He worked for the Michigan Department of Conservation. As a first step, he caught lampreys and put them in tanks with fish and watched how they caught and killed the fish. He watched lampreys lay eggs in rivers near the lakes. He collected the eggs and found out how long they took to hatch. He learned all he could about the life and ways of the sea lamprey.

(Continued on the next page)



Dr. Applegate learned many things about the lamprey, but one clue was more important than any other. He found that around the Great Lakes, lampreys laid their eggs only in streams. Each year, adult lampreys left the lake, swam up a stream, laid their eggs, and then died. He also learned that it takes *four to six years* for young lampreys to develop into full-grown adults. It was only the adults, he knew, that killed fish.

About this time, Dr. Applegate was asked to join the United States Fish and Wildlife Service. Dr. James W. Moffett, in charge of Great Lakes Fish Investigations, told Applegate they had to stop the lamprey, somehow. He could help greatly in the work. Dr. Applegate jumped at the chance and soon set up his laboratory near Hammond Bay, Michigan.

But how could the lampreys be stopped? Dr. Applegate wondered if he could stop them by keeping the adult lampreys out of rivers and streams. If so, they would not be able to lay their eggs. Soon, the lampreys would be gone.

A Fence for Lampreys

He built a strong fence, called a *weir,* across a nearby river. At first it seemed to work. It kept lampreys from getting up the stream to lay their eggs. But then came trouble. Sticks and leaves floated down and caught on the weir. Soon it was plugged and water flowed over the top. Then a floating log tore a hole in the weir. Some lampreys got through. Since each lamprey can lay about 60,000 eggs, even a few could ruin the whole project. Dr. Applegate decided that this kind of weir would not work.

Next he tried electrical weirs. These were fences too, but instead of wire, a charge of electricity in the water blocked the way. From experiments in his lab, Dr. Applegate knew that lampreys cannot swim through electrically charged water. The electrical weirs were made of metal rods that carried the electricity down into the water. The rods dangled freely in the water from a long wire stretched above *(see photo).* Logs and leaves floated underneath.

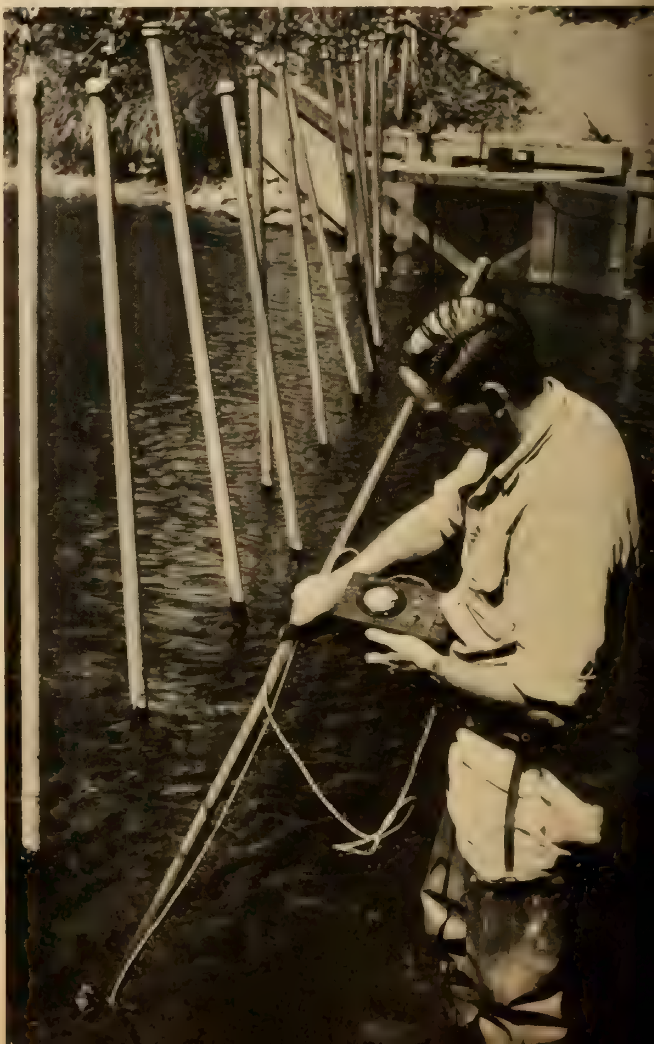
But one night a storm stopped the electricity and again some lampreys got through. Also, the weirs were very expensive. And what if a person got too close to one of these weirs? An electrical shock would be dangerous.

So Applegate and Moffett turned to their last hope. There was only one other way, and that was poison. They needed a poison that would kill one kind of creature but not others. Such poisons had been found for certain insects, but never for fish-like animals like lampreys.

The poison they hoped to find would have to kill only lampreys, not fish. It could not injure cows or deer or birds or other animals that might drink the stream water. Applegate and Moffett didn't even know if such a poison could be made or where to start looking. They might never find it. They decided to just start testing every chemical they could find.

Applegate went back to his laboratory and set up rows of test tanks, putting a fish and a lamprey in each. He got samples of different chemicals and started testing them by putting each chemical in a tank and noting its effect on the fish and lamprey.

Another biologist named John H. Howell came to help. The first month they tested several dozen chemicals. Then they tested more dozens. Soon they had tested several hundred. After a year, they had tested over 1,000 chemicals. Still no luck. More months passed, and then two years . . . three years . . . four years. Applegate and Howell kept searching and hoping.



Biologists tried barriers called *electric weirs* to stop lampreys from going up streams to lay eggs. But these weirs proved to be too expensive, especially in streams far from towns and highways.

In Lake Superior, lake trout were nearly wiped out by the sea lampreys. Then biologists began to use the lamprey poison. Now fishermen are beginning to catch big lake trout like these once more.

Dead Lamprey, Live Fish

Then one day at Hammond Bay, after testing more than 6,000 chemicals in six years, John Howell checked one of the tanks and found that the lamprey was dead, but not the fish. This had never happened before. He talked to Applegate and they decided to try the same compound again the next day. The same thing happened. There was the lamprey—dead. And there was the fish—still alive. The two men looked at each other. Had they really found it after all these years?

They began to get excited. They ran more tests using little lampreys and little fish, big lampreys and big fish. They tried cold water and warm water. Each time, the chemical worked. At last, they had found the poison that would kill lampreys. Now if it would only work when tested in a real stream.

For this final test they picked a creek close to their laboratory. They knew many lampreys lived in the stream. The date was October 29, 1957. All that afternoon and night, the poison trickled from a pipe into the stream. The two biologists waited and wondered. The poison had worked so well in a laboratory. But would it work here in the stream?

When biologists tested the lamprey poison in a stream, they found many young lampreys dead. The fish in the stream were not affected by the poison.

When dawn came, they hurried along the stream. "There's a dead lamprey!" Applegate shouted. "Here's some more!" Howell called. Downstream, Moffett found a whole tangle of young lampreys, all dead. None of the fish in the stream were dead. The first real test was a success, and now the biologists began to talk about using the lamprey poison in every stream around Lake Superior.

The discovery of the poison came none too soon. The lamprey had destroyed nearly all of the lake trout in Lake Superior. Only a small number were left in the western end of the lake. After a few more stream tests, Howell took a field crew and started treating all the streams around western Lake Superior.

Since part of Lake Superior is in Canada, biologists from the Fisheries Research Board of Canada helped, too. They treated streams on their side of the border. All this work was organized for both nations by the Great Lakes Fish Commission, a group of men representing both Canada and the United States.

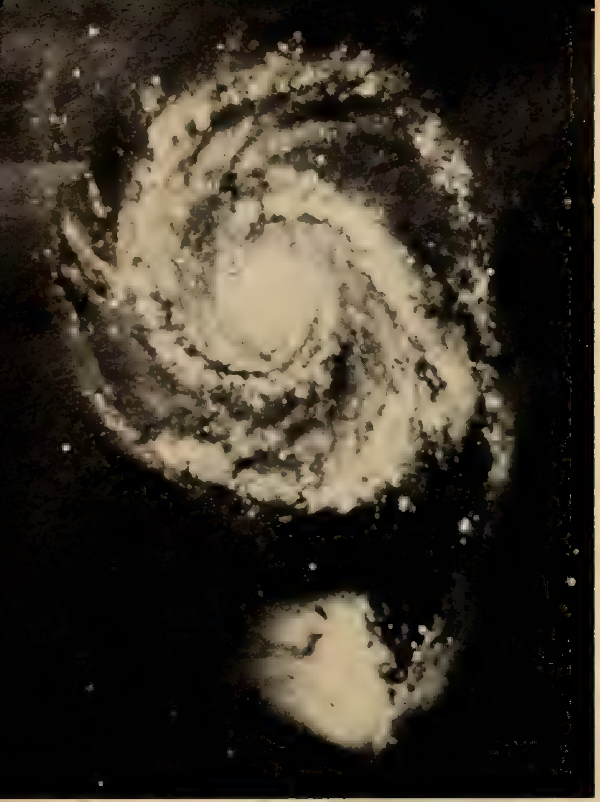
Gradually, the field crews moved around the lake, treating each river and stream in turn. By the fall of 1960, all Lake Superior streams had been poisoned. By the spring of 1961, biologists found only about one-eighth as many lampreys as usual in the streams.

Soon, stream treatment work began around Lake Michigan. This year, most work is centered on Lake Huron. In a few years, Lake Erie and Lake Ontario will be treated. Hopefully, some day nearly all lampreys will be gone from all the Great Lakes.

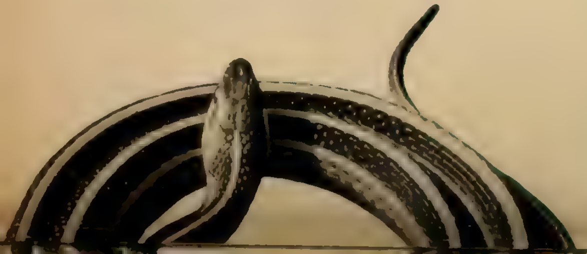
Fishery biologists are stocking new supplies of trout and salmon in Lake Superior and Lake Michigan. More will follow as soon as Lake Huron and the other lakes are cleaned of lampreys. Fishing boats that have been tied to docks for years are going back to work. In many places, fishermen are already beginning to catch big fish once again. The fight against the sea lamprey is being won ■

WHICH IS IT?

The sea lamprey is sometimes called a *parasite*—an organism that lives on or in another organism. Although parasites are usually harmful to the plant or animal on which they live, they usually don't kill their "hosts." Do you think that lampreys should be called parasites? Or should they be called predators?



The biggest spirals we know in nature are galaxies, vast collections of stars like our own star system, the Milky Way. The one shown here is the Whirlpool galaxy in the constellation Canes Venatici. The speed of rotation of the galaxy at its center is greater than its speed of rotation at the outer edge. These differences in rotational speed are thought to give the galaxy its spiral shape. The galaxy's several bright "arms" make the Whirlpool galaxy several spirals in one.

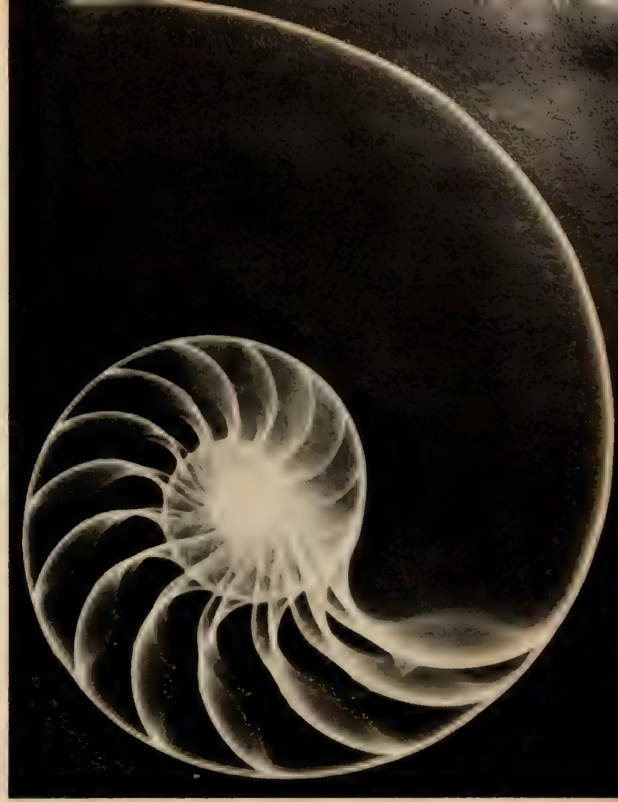


HOW NATURE DOES THE TWIST

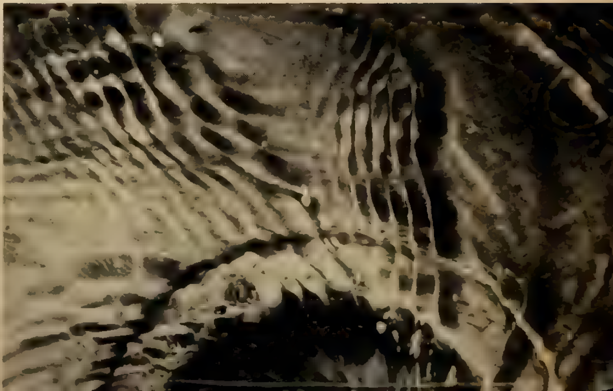
Spirals have been called the curves of life because they are found in so many living things. The graceful sweep of a snail's shell, the curve of a ram's horn, a snake coiled to strike—all are examples of spirals. Your hair grows in a spiral from a point near the top of your head. If you can find a boy with short hair, find out which way his hair spirals—to the right or to the left.

The world of non-living things also displays a wealth of spirals. They range from tiny swirls of water in a country brook to the destructive spirals of hurricanes and tornadoes. Nature's biggest spirals take the form of galaxies. Our own galaxy, like the one shown on these pages, is a spiral.

With shells, as with human hair, right-handed spirals seem to be more common. A shell spiral begins at the center and grows outward. In tornadoes, hurricanes, and



This X-ray photograph of a chambered nautilus (sea shell) clearly shows that as the animal grows it spirals outward. The outer shell line continues to wind around the core in an ever-widening curve.



A coiled ribbon snake, like the coil of rope in the diagram, forms a true spiral. How do you think the snake arranges itself in a spiral —from the head outward, or from the tail inward?

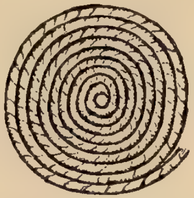
A "twister," or tornado, is one of the most destructive spirals known to man. Air rushing in toward a central point sets up a cone-shaped spiral of wind moving at speeds of 300 miles an hour or more. The direction of motion of the air forming the spiral of tornadoes and hurricanes is from the outside toward the center of the storm in a counterclockwise direction.

The photographs on these pages show you some of nature's spirals.

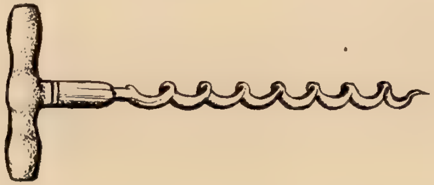
—Margaret R. Cooper

WHAT MAKES A SPIRAL SPIRAL

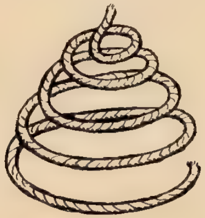
You can make a spiral very easily. All you have to do is coil a length of rope around itself, as shown here.

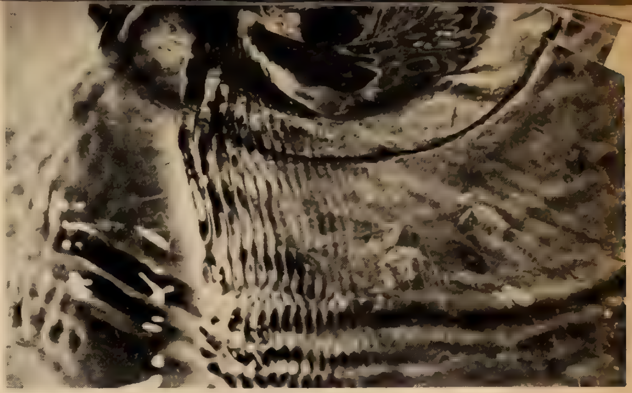


Vines are said to "spiral" upward as they grow. And a corkscrew is sometimes called a "spiral." But neither one is a true spiral. To the mathematician, a *spiral* is a curve that starts from a point and gets less and less curved as it gets farther from the point where it started.

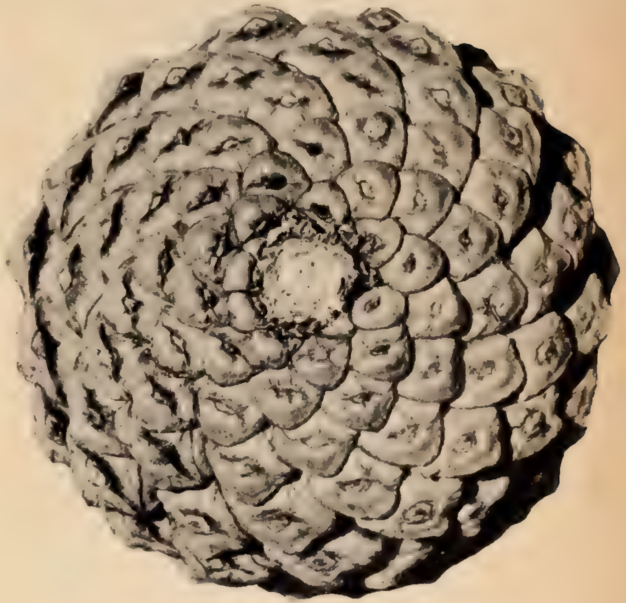


The continuous curve of a corkscrew, as shown in the diagram, does not change its curvature as it twists from its starting point. A curve like this is called a *screw* or a *helix.* If you lifted the center end (starting point) of the coiled rope, as the diagram shows, you would make a shape similar to a corkscrew, but a shape that would be a true spiral.



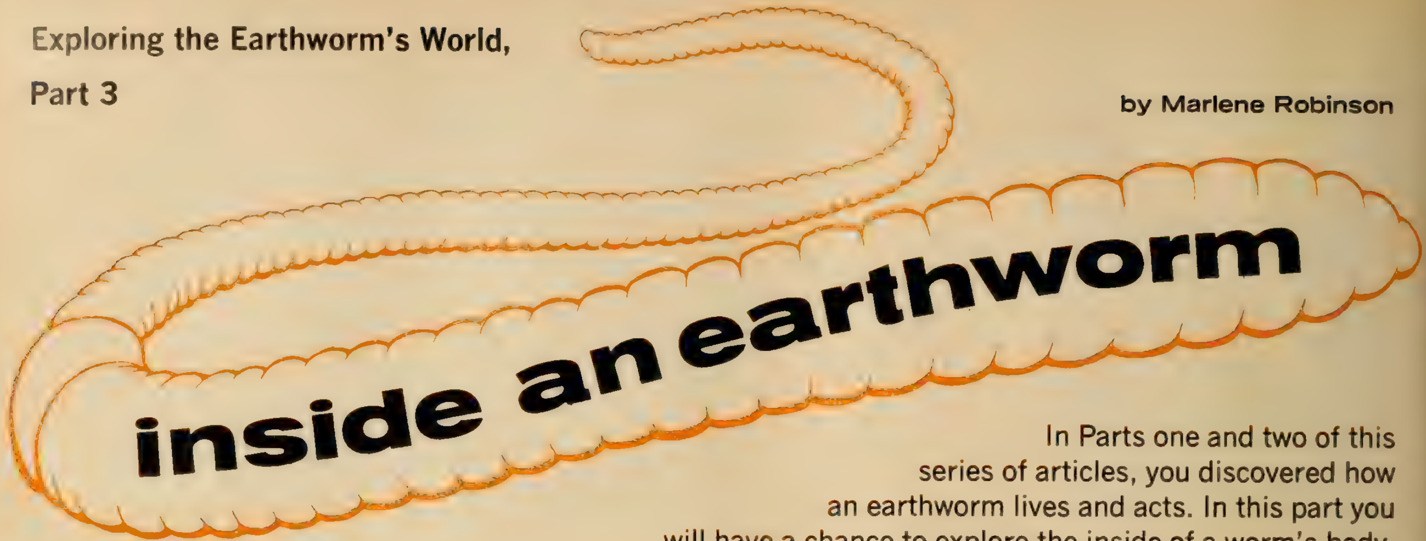


Nearly every time you pull the plug out of the bathtub or the sink, you start a spiral of water. Draining water is an example of a spiral that has a starting point at the outer edge and twists in on itself toward the center.



The seed-bearing scales of a pine cone grow outward in a true spiral pattern from the center of the cone's base, where it is attached to the branch.

Exploring the Earthworm's World, Part 3



inside an earthworm

by Marlene Robinson

In Parts one and two of this series of articles, you discovered how an earthworm lives and acts. In this part you will have a chance to explore the inside of a worm's body.

■ An earthworm is a long tube divided into rings or segments. Every segment has a pair of nerves inside and bristles *(setae)* outside. With a hand lens, you can find tiny holes on the underside of each segment. These are pores through which the worm releases a waste liquid that keeps its outer skin moist.

These are some of the things that make an earthworm special. Many other types of worms are not considered to be as "advanced," or complicated, as the earthworm. For instance, another important "advance" is the fact that an earthworm has an opening at the head end–its mouth—and another opening at the tail end. Food material that is not digested is passed out from the tail end in the form of *castings*.

Flatworms have only one opening in their bodies. This may not seem important, but it limits every other structure in the flatworm. Blood, food, and waste mix and circulate freely inside the body of the flatworm. This limits the amount of energy a flatworm can get from its food, so a flatworm must keep close to its food supply.

In the earthworm, however, food and waste are kept separate. The blood flows in blood vessels, in a system somewhat like the one in humans.

Getting Ready To Dissect

You can see the entire digestive system of the worm as well as many other important parts of a worm by cutting open *(dissecting)* an earthworm. By exploring a worm's insides you may better understand why a worm acts as it does and why it lives where it does.

Pick the largest earthworm you can find. It should be six to eight inches long. You will want an adult worm, and you can find one by counting the segments. An adult has from 115 to 200 segments.

Put the worm in the freezer overnight. This will kill it without damaging it in any way. Let it thaw for about 45 minutes before you are ready to dissect.

While you are waiting for the worm to thaw you can gather tools and be setting up your "lab." You should have a *dissecting pan,* which is simply a pan with a smooth, fairly thick layer of wax in the bottom. As you dissect, you will need to hold back the skin and muscle layers with pins; the wax provides a firm surface for holding the pins. (DO NOT TRY TO MELT WAX INTO A PAN YOURSELF. Wax catches fire easily, so it is dangerous to heat without help from an adult.) If you can't make a dissecting pan with wax in it, use a large, flat piece of cork or balsa wood on which to pin your worm.

Have about 20 straight pins handy so that you can pick them up quickly when needed. These can also be used as probes. You will also need a hand lens or magnifying glass. Most important of all, have a pair of sharply pointed scissors (such as cuticle scissors). It is impossible to do careful work without a good cutting tool. A pair of tweezers *(forceps)* will help you to hold the body walls back while cutting.

Arrange these items on a table where you can sit comfortably beneath good light. You will get tired if you have to stoop over the whole time or strain your eyes.

Finding Eggs and Muscles

Before you set to work, study the diagrams on these pages so that you will know what you are looking for. Arrange the worm in a straight line with the top *(dorsal)* side up. Pin the head end down through the lobe over the mouth. Pin the hind end through the last lobe.

First, locate the *clitellum (see Diagram 1)*. In most worms it will be a light colored, somewhat enlarged section located around the 31st to 37th segments. The clitellum is an extra layer of skin covering four or five segments.

After earthworms have mated and eggs have formed, the clitellum moves forward, slips off the head end of the worm, and forms a rubbery envelope for the eggs. You can sometimes find these egg sacs in earthworm soil, even though they are tiny. (If you find a worm without a clitellum, what do you suppose has happened?)

Begin to cut about an inch in back of the clitellum. Lift the skin with your tweezers and slip the sharp point of the scissors through the skin, aiming toward the hind end. Snip only the very top layer all the way to the end. Inspect the opening with your hand lens. You will see the thicknesses of the body walls.

Can you find three layers in the body wall? On the outside is a membrane covering called the *cuticle*. Beneath that is a layer of circular muscles that fit together like a stack of rings. Beneath this layer is another muscle layer that runs the length of the worm *(see Diagram 2)*. Can you see how this two-way stretch helps the worm to move?

If you squeeze a tube of toothpaste by wrapping your fingers around it, the paste moves forward. This is how the ringed muscles work in the earthworm. The little setae then clamp down so that the worm does not slip backward. Next the long muscles squeeze together, pulling the tail end up toward the head end.

Intestines and Blood Vessels

When you cut through the inner layer of muscles you will see the thin wall of the intestine. You can probably tell what is inside the intestines. Gently press along the intestine like a muscular wave running the length of the worm. What happens?

Now with your tweezers and scissors, cut the intestine away from the body walls. As you cut through each segment you will see a thin membrane. These are the walls that keep each segment separate from every other one. The earthworm is rather like a stack of life-savers, with the intestinal tract filling the middle hole.

As you separate the tract, pin the body walls flat *(see Diagram 3)*. Lift up the tract so that you can inspect it closely from all angles with your hand lens. Note how many blood vessels encircle it. You will find more little red lines of blood vessels in the body walls. Can you tell by the "redness" of the worm where most of the blood vessels are located?

There are two main blood vessels: one on the top side of the worm and one on the underside. They will probably look like black lines. You can even see these from the outside of the worm. The top blood vessel carries digested food forward, serving each part of the worm that needs it. The hearts, which are near the head end, then pump the blood down to the main vessel on the underside. This blood vessel carries waste liquids to the pores where they pass from the body.

Exploring the Front Part of the Worm

Next, with your scissors and tweezers clip the body walls from the clitellum to the lobe at the head of the worm *(see Diagram 4)*. Loosen the remaining organs very carefully and pin back the walls as before.

Just forward from the intestine is the *gizzard (see Diagram 5)*. You will have no trouble finding it if you look for a muscle tough enough to grind up leaves and dirt and beetle shells. The gizzard is white and usually the top blood vessel shows clearly upon it. *(Continued on the next page)*

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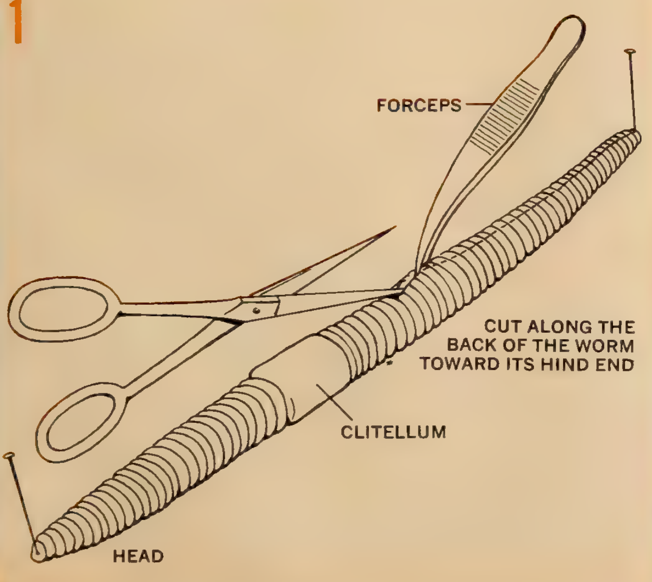

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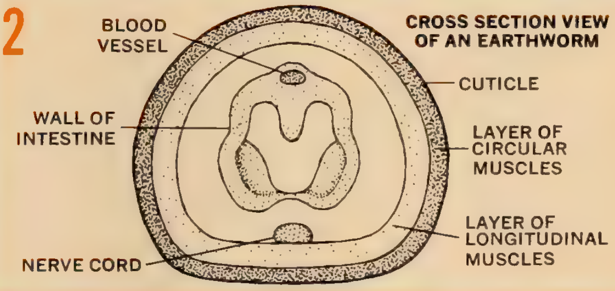
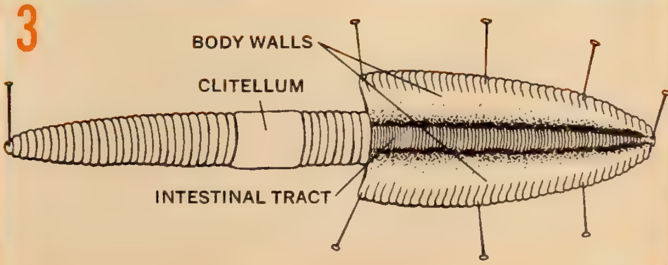

BLOOD VESSEL
CROSS SECTION VIEW OF AN EARTHWORM
CUTICLE
WALL OF INTESTINE
LAYER OF CIRCULAR MUSCLES
LAYER OF LONGITUDINAL MUSCLES
NERVE CORD

3



This gizzard is so tough that it is difficult to pull apart. You can try if you carefully remove it from the other organs. How does it compare with the strongest muscle in your body?

The enlarged section just in front of the gizzard is the place where food is stored before passing into the gizzard to be ground up. This "storage tank" is called the *crop.* (Some other animals have crops. Can you name one?)

Ahead of the crop is a section of the digestive system called the *esophagus* (e-*soph*-o-gus). You will find five pairs of tubes circling the esophagus. These are all hearts. They do not look like human hearts, but they work in a similar way. Why do you suppose the earthworm has five pairs of small hearts instead of one big one?

Clustered near the worm's fourth and fifth segments *(see Diagram 5)* are soft white clumps. These are gatherings of nerve endings, and they connect to the large, similar cluster in segment 3 that is the main brain. If you have dissected carefully you will find both the brain and these "sub-brains."

In these clusters the messages of "smell," "taste," "pain," and other sensations become memories that enable the worm to learn where to find food, when to move away from strong light, and what places to avoid. Small as these clusters are, they enable the earthworm to learn and remember.

These brains send and receive messages from the long nerve cord running the length of the worm. Look for this white thread lying beneath the intestine. Can you find out how it connects with each segment?

Returning to segments 7 through 11, look beneath the hearts for three pairs of firm white glands. These are important glands for the worm; they *secrete,* or send out, a substance that *neutralizes,* or weakens, the acids in the plant foods that earthworms eat. Why are they located just behind the esophagus? What would acids do to the delicate tissue of the intestine?

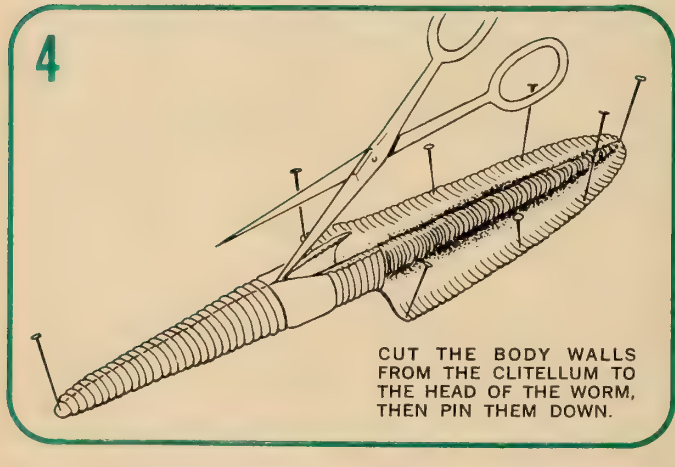
You can inspect the mouth opening by inserting the tips of two pins, then gently pulling the tube open. There is quite a bit of stretch there. Now you see how the worm can swallow large clumps of earth and parts of leaves.

Now that you have seen the basic structure of an earthworm, you probably have a better idea of why it lives in the soil and not in a desert or in trees.

The earthworm eats what its system can manage to change into energy. It lives where it will find these foods and where it will be protected from conditions its body cannot survive, such as too much light, water, or heat. The earthworm's muscles, hearts, brain, and all the other parts of its body are adapted to help the worm survive in its soil world ■

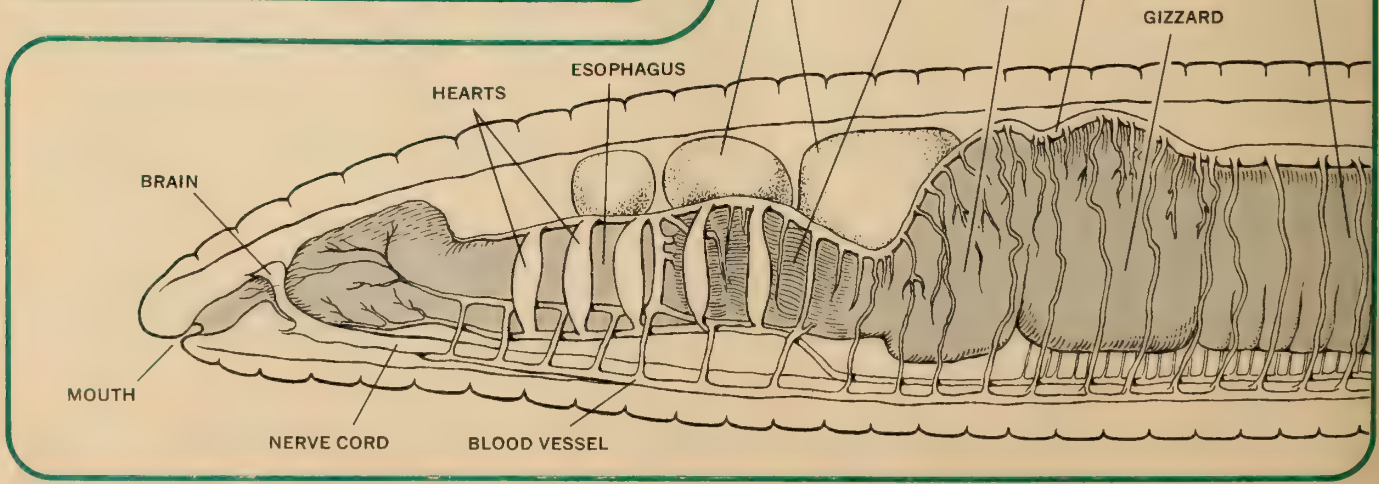
■ An excellent small book on the earthworm, with colored illustrations of the animal's parts, is: **The Earthworm,** by Albert Wolfson and Arnold Ryan, Harper and Row, New York, 1955, $2.40.

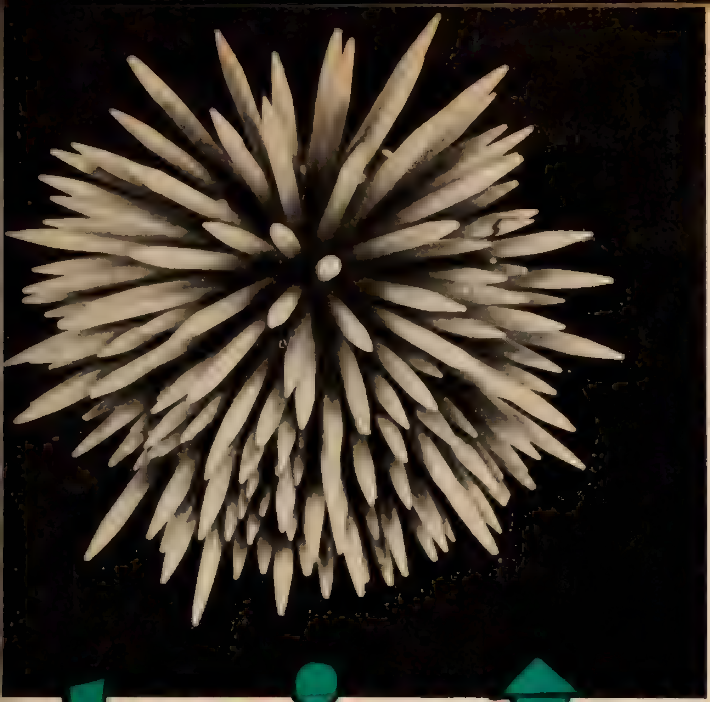
4



CUT THE BODY WALLS FROM THE CLITELLUM TO THE HEAD OF THE WORM, THEN PIN THEM DOWN.

5





brain boosters

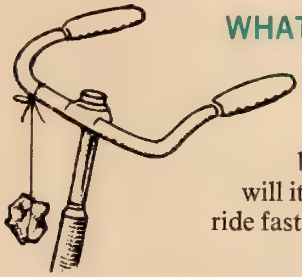
prepared by

DAVID WEBSTER

MYSTERY PHOTO

What is it?
Suggested by Larry James, Charlotte, North Carolina

WHAT WILL HAPPEN IF?



Hang a little weight on a string from your bicycle handlebars. What will it do as you start pedaling, ride fast, turn a corner, and stop?

FUN WITH NUMBERS AND SHAPES

Which is the biggest number?

23

.0000000000000001

MMMMMMMDCCCLXXXVIII

9999 × 9999 × 9999

100,000,000,000,000

FOR SCIENCE EXPERTS ONLY

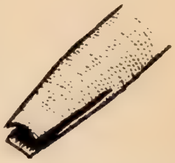
Four boys had a tug of war with a piece of thin rope. Two boys pulled hard on each end, but the rope did not break. Then the boys tied one end of the rope to a tree and three of them pulled. This time the rope did break. Can you explain why the rope broke with three boys pulling, but did not when four pulled?

CAN YOU DO IT?

Can you place six matches so that each one touches all the others?

JUST FOR FUN

You can make a little horn with a paper straw. Squeeze together one end and snip off the corners (*see diagram*). Put the cut end into your mouth and blow. Can you make a noise? What happens to the sound as you cut the straw shorter and shorter?

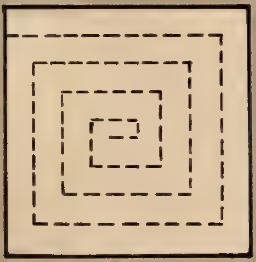


For answers to these Brain-Boosters, see the next page.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: Since the weight of the boy is supported by hundreds of nails, his feet push only slightly on each one.

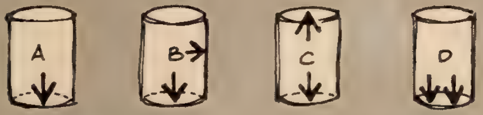
Can you do it? This is one way to tear a long strip from a sheet of paper.



For science experts only: The problem was to figure out a way to have a race that would be won by the man whose horse ran slower. This could be done by having each of the two men ride the other man's horse.

Fun with numbers and shapes: Here is how to fill in the squares so that no two consecutive numbers are in squares that touch each other.

	3	5	
7	1	8	2
	4	6	



What will happen if? Soda will come out the bottom hole in Can B and in Can C. Will soda come out either of the two holes in the bottom of Can D if it is tipped?

Investigating Wildflowers

■ In the early summer, the countryside is green, green, green with growing plants. In all, plant scientists estimate that there are over 300,000 different kinds *(species)* of plants scattered over the world, from lofty trees to rock-hugging lichens.

Each of these species differs—a little or a lot—from other kinds of plants. Some grow well in shade; others must have plentiful sunlight. Some need lots of water; others need little. Some flower in spring; others in late summer. Each species is adapted to survive in different ways.

When a plant grows is often as important as where it grows. As the seasons change, so do the conditions that affect plants—the amount of sunlight each day, the temperature, the amount of rainfall. Plants are adapted to these changes too, with some kinds flowering and developing seeds early in the spring, others in the summer, and still others late in the fall.

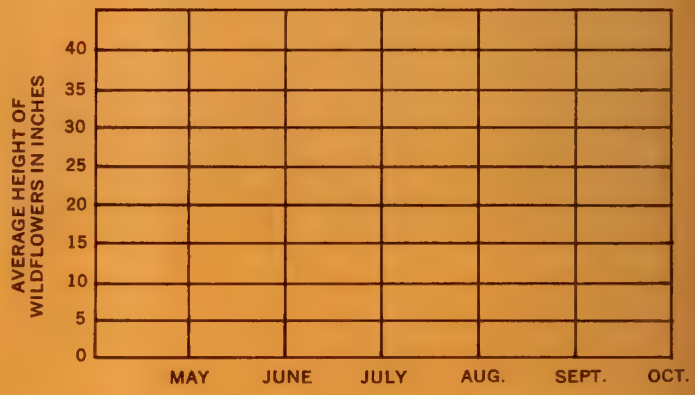
Short Flowers, Tall Flowers

This spring and summer, you might want to investigate some of the differences—and similarities—in different kinds of plants. Take wildflowers for example. How many different kinds can you find growing in your neighborhood? (Even if you live in a city you can probably find a few.)

You might take notes on the lives of different kinds of wildflowers as they change with the seasons. For example, how does the height of the plants vary as the months go by? Are the wildflowers that blossom in May as tall as those that bloom in June?

In May, try to find at least five different kinds of wildflowers in bloom. Measure the height of the blossom above the ground in about 10 different specimens of each kind of plant. By taking an average of all your measurements, you will have an idea of the height of wildflowers in May. Do the same thing in June and in each succeeding month in which you find wildflowers.

As the months pass, you can plot the results of your investigation on a graph like the one shown on this page.

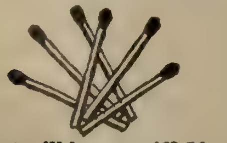


Make a dot for the average height of the wildflowers in your area each month. Later you can connect the dots with straight lines. Does the average height of wildflowers increase, decrease, or stay about the same? Can you suggest a reason for this? Do you think you will find the same plants flowering in August as you find in May?

—CHRISTOPHER HALE

ANSWERS TO BRAIN-BOOSTERS ON PRECEDING PAGE

Mystery Photo: The Mystery Photo shows the top of a bunch of round toothpicks in a small glass.



Can you do it? Here is how you can place six matches so that each one touches all the others.

What will happen if? If you hang a weight on your bicycle handlebars, it will swing back as you start, and forward as you stop. When you turn a corner, the weight will lean toward the outside of the curve. It will hang almost straight when you are riding fast.

Fun with numbers and shapes: 100,000,000,000,000 is the biggest number.

For science experts only: Two boys pulling on a rope tied to a tree can pull no harder than can two boys pulling on each end of the rope. When three boys pull on a rope tied to a tree, the tree "pulls back" on the other end of the rope the same as if three boys were holding it.

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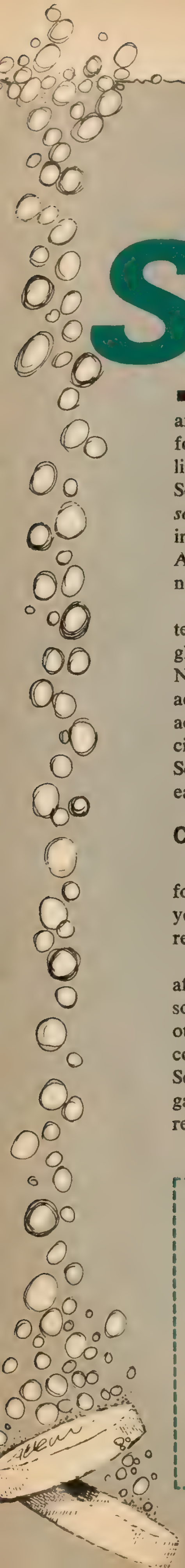


SPEEDING UP YOUR REACTIONS

BY ROBERT GARDNER

■ Drop an Alka-Seltzer tablet into a glass of water, and you will see bubbles of a gas called *carbon dioxide* form and rise to the top of the liquid. If you read the list of "active ingredients" on the label of the Alka-Seltzer bottle you will find that the tablets contain *sodium bicarbonate* and *citric acid*. The citric acid is in the form of crystals, like crystals of sugar or salt. As long as it and the sodium bicarbonate are dry, nothing happens.

To see what happens when they are wet, put a teaspoonful of *baking soda* (sodium bicarbonate) in a glass and add some water. Do any bubbles of gas form? Now put some baking soda in a clean, dry glass and add some lemon juice. (Lemon juice contains citric acid dissolved in water.) What happens when the wet citric acid and the sodium bicarbonate come together? Scientists say that the two substances are *reacting* with each other, and what happens is called a *reaction*.

Changing the Speed of a Reaction

Now that you know what causes carbon dioxide to form when Alka-Seltzer is dropped into water, can you think of some things you could do to make the reaction go faster? To make it go slower?

Do you think the temperature of the water will affect the speed with which the citric acid and the sodium bicarbonate in the Alka-Seltzer react with each other? To find out, place equal amounts of hot and cold water in two small glasses and drop an Alka-Seltzer tablet into each glass. In which one does the gas seem to be forming faster? Does the speed of the reaction depend on temperature?

Suppose you place a whole tablet in one glass of water and a tablet which has been crushed into small pieces into a second glass of water. Which tablet do you think will react faster? In doing this experiment, why should the temperature and amount of water in each glass be the same? Can you offer any explanation for your results?

In the two experiments you have just done, you used equal amounts of water. Does the amount of water affect the speed of the reaction? How can you find out?

Will the speed of the reaction depend on the amount of Alka-Seltzer you use? Take two identical glasses of water. Into one drop ½ tablet of Alka-Seltzer; into the second, drop a whole tablet. In which container is the gas produced faster? (If the speed were the same in both glasses, the ½ tablet would take half as long as the whole tablet to react completely. Why?) How long will ¼ tablet take to react?

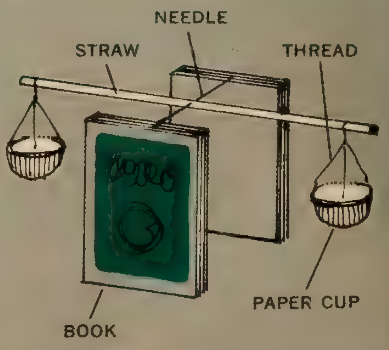
Suppose you drop an Alka-Seltzer tablet into a glass of water in which several other tablets have reacted so that the water contains dissolved carbon dioxide and other ingredients from those tablets. Do you think the reaction will be faster, slower, or the same as in a fresh glass of water? Is it?

Will the citric acid and sodium bicarbonate in Alka-Seltzer react in liquids other than water? Pour equal amounts of vinegar, rubbing alcohol, lemonade, salt water, baking soda and water, milk, and so on in different glasses and test each liquid with an Alka-Seltzer tablet. Is the reaction any different in the various liquids? Is it faster or slower than in water? Why? ■

INVESTIGATION

Bromo-Seltzer contains citric acid and sodium bicarbonate too, but in tiny pellets instead of larger tablets. In which form do you think these chemicals will react faster? To find out, use a simple balance scale like the one shown here to get equal weights of Bromo-Seltzer and Alka-Seltzer. Drop the samples into two glasses containing equal amounts of water at the same temperature. Which finishes reacting first?

Do you think it would make any difference if you put the two samples into dry glasses, then poured equal amounts of water into each glass? Try it and see.



(continued from page 2T)

Inside an Earthworm

People are often surprised to find a number of complex organs inside an earthworm. By dissecting worms, or by at least discussing their parts, your class may better understand how worms are adapted for life in the soil.

Topics for Class Discussion

- *Why is it important for an earthworm to have a closed circulatory system?* Having blood flow in vessels keeps it from mixing with wastes (as in some other kinds of animals) and is a more efficient arrangement.
- *Are any of the earthworm's digestive organs similar to those of humans?* Some of these organs have the same functions and names. In humans, the stomach does the digestive work of the earthworm's crop and gizzard. (Another familiar animal with a crop and gizzard is the chicken.)
- *How do earthworms reproduce?* The article describes the function of the clitellum, and Diagram 5 in the article shows the locations of the sperm sacs. Earthworms reproduce sexually, with the union of sperm and egg cells (*see* N&S, *March 27, 1967*). Both male and female parts are found in each worm. One worm, however, is not both the father and mother of its offspring, since there is no contact between the sex cells within a single earthworm.

When earthworms mate, two worms exchange sperm cells *(see diagram)*. Later, each worm sheds its eggs and the sperm it received from another worm into the clitellum. Fertilization occurs in the clitellum. Later the clitellum slips off the body of the worm and a mucous secretion from the worm's skin seals each end, forming a protective sac for the developing worms.

Reference

A useful book for dissecting earthworms and many other animals is *How To Dissect,* by William Berman, Sentinel Book Publishers, Inc., New York, 1961, $1 (paper).

Speeding Up Your Reactions

This simple investigation into ways of changing the rate of reaction between sodium bicarbonate and citric acid should start your pupils thinking about why the methods they tested worked or did not work.

Topics for Class Discussion

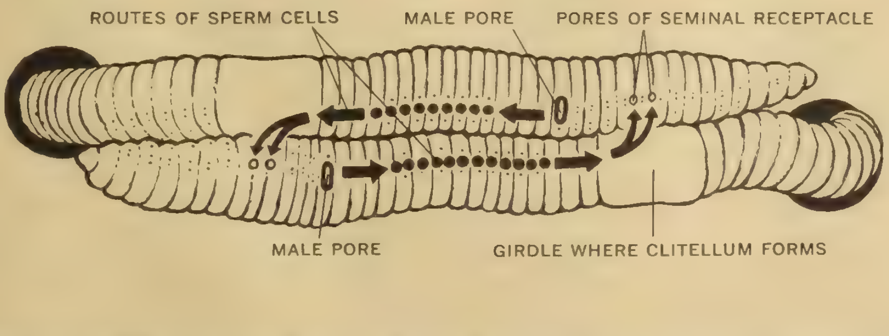
- *Why do these two chemicals react when an Alka-Seltzer tablet is put in water?* Before many substances will react with each other, their particles (molecules) must strike against each other. When the solid tablet dissolves in water, the molecules of sodium bicarbonate and citric acid break up into *ions,* and these ions are free to move around and bump into each other.
- *How does heat speed up reaction?* Heat speeds up the motion of the molecules, producing more and harder collisions between them.
- *How does breaking up the tablet into small particles before you put it in water speed up the reaction?* The surface area of all of the particles is greater than that of the tablet, so the water can dissolve them much faster than it dissolves the tablet.
- *How does the amount of Alka-Seltzer in a given amount of water affect the reaction?* In a very small amount of water, two tablets will take longer to dissolve than one. But whatever the amount of water, more tablets will produce a "stronger" solution—in this case, more carbon dioxide (and other ingredients of the tablets).

You might point out that laundry bleach reacts with substances in cloth to lighten its color. If too much bleach is put in the wash water, the solution reacts too fast and eats holes in the cloth. If not enough bleach is put in the water, the clothes may come out unchanged in color.

- *How does striking a match produce fire?* Fire is a rapid reaction between oxygen and some other substance. At ordinary temperatures, the substances in a matchhead and stick react so slowly with the oxygen in the air that the match does not catch fire. When you strike a match against a rough surface, friction heats a small area of the matchhead enough to speed up the reaction tremendously, and this reaction gives off enough heat to start the rest of the match burning.
- *Why does rust form on bicycles and other objects made of iron or steel that have been left out in the rain? How can you protect them against rusting?* Oxygen in the air reacts with iron to produce *iron oxide,* or rust, and water speeds this reaction. A coating of oil, grease, or certain paints will shield the metal from the air.

Activity

Will an (uncoated) iron nail or bolt rust faster under water or in the air outdoors? Your pupils can find out by putting one nail under water in an open glass jar and leaving the other exposed to the air—both outdoors. (They may have to add water now and then to keep the nail covered.)



When earthworms mate, they lie on their sides like this. Sperm cells come from each male pore and travel along the worm's body until they enter the pores of the seminal receptacles of the other worm.

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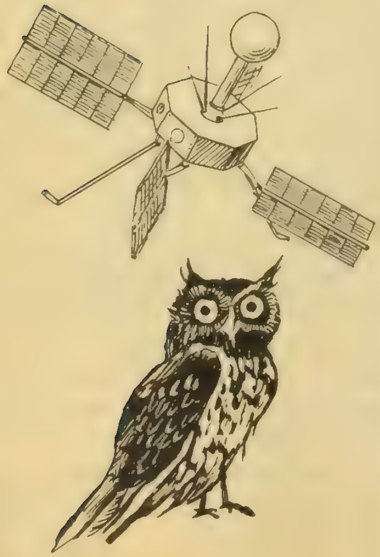

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VOL. 4 NO. 17 / JUNE 26, 1967

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EXPLORING A FIELD

nature and science
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Exploring Life in a Field

by Laurence Pringle

The plants and animals that live in a field are continually changing. Here is how you can find clues to these changes in a nearby field, meadow, or vacant lot.

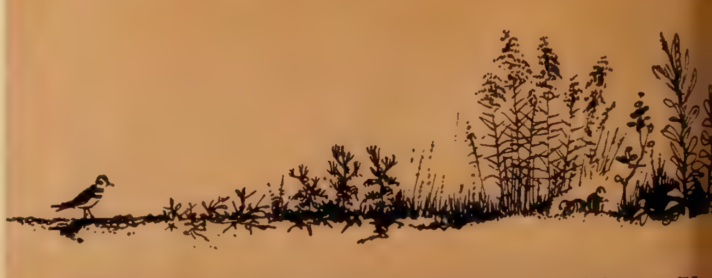
■ When you think of summer fun, you probably don't thin first of fields, meadows, or vacant lots. Such places can' compare with, say, an ocean beach with the surf up. Bu most of us can't spend all of the summer at the beach Part of a summer exploring a nearby field can also be fu

It can be any sort of field. If you live in a city, you ca explore a vacant lot *(see "How Vacant Is a Vacant Lot?" on page 4).* If you live in the suburbs, in a small town, o in the country, you will probably have a greater choice o fields to explore. The important thing is to pick one, the visit it often to see what is going on.

Try to pick a field that has a variety of plant life in i including some shrubs and tall weeds. The more varie the plants, the more varied the animals that live with th plants. (You might check this idea yourself by comparin the insect life in two different fields, one with a great variet of plants, the other with mostly one kind of plant.) Als you don't have to choose a big field. A biologist once wro

FROM FIELD TO FOREST

Beginning with bare soil on the left, this drawing shows ho a field slowly changes from open land to a forest. As th plant life changes, so does the animal life. This drawin shows plants and animals that might be found in fields o the northeastern United States; you may find a differen succession of plants and animals in your area.



This is your summer issue of Nature and Science. Yo will receive your next issue early in September.

book called *A Lot of Insects,* based entirely on the insects at visited the city lot where he lived.

egin with a Map

A field is the home of a community of plants and nimals. One of the goals of your visits to a field can be to iscover what kinds of plants and animals live there and ow they fit into the community. At first glance, a field ay look lifeless. You may see some birds or butterflies ying over, but nothing much seems to be happening in e field itself. Move into the field, however, and you will egin to discover the complex community that lives there.

On your first trip to a field, just walk around and ex-lore the whole area. You should keep notes on your bservations *(see "Keeping a Field Journal," page 13).* ake a rough map of the field, marking landmarks such s an outcrop of rock or a hedgerow boundary. Pace off e edges of the field so that you can draw your map to cale (such as one inch on the map equals 100 feet on the eld).

On later trips, you can concentrate on a particular part f the field that interests you, or on certain plants or nimals. The other articles in this issue may give you ome ideas of things you can observe.

rom Field to Forest

"Change." Keep this word in mind as you explore a eld. A field is always changing, although the changes ay be too slow to be seen in one visit. Over the summer, owever, you may see some changes and also find clues bout past and future changes in the field.

You may have seen a lawn, garden, or farmer's crop-nd that became a weed-grown field when it was aban-oned. This is how most weedy fields begin—as bare soil r a planted field. On the prairies of the central United tates, abandoned farm land changes into grassy fields nd stays that way. There isn't enough water for trees to row, except along streams or ponds. In most other parts of the country, however, a field is just an early stage in a long series of changes that lead to a forest. Here is how it happens:

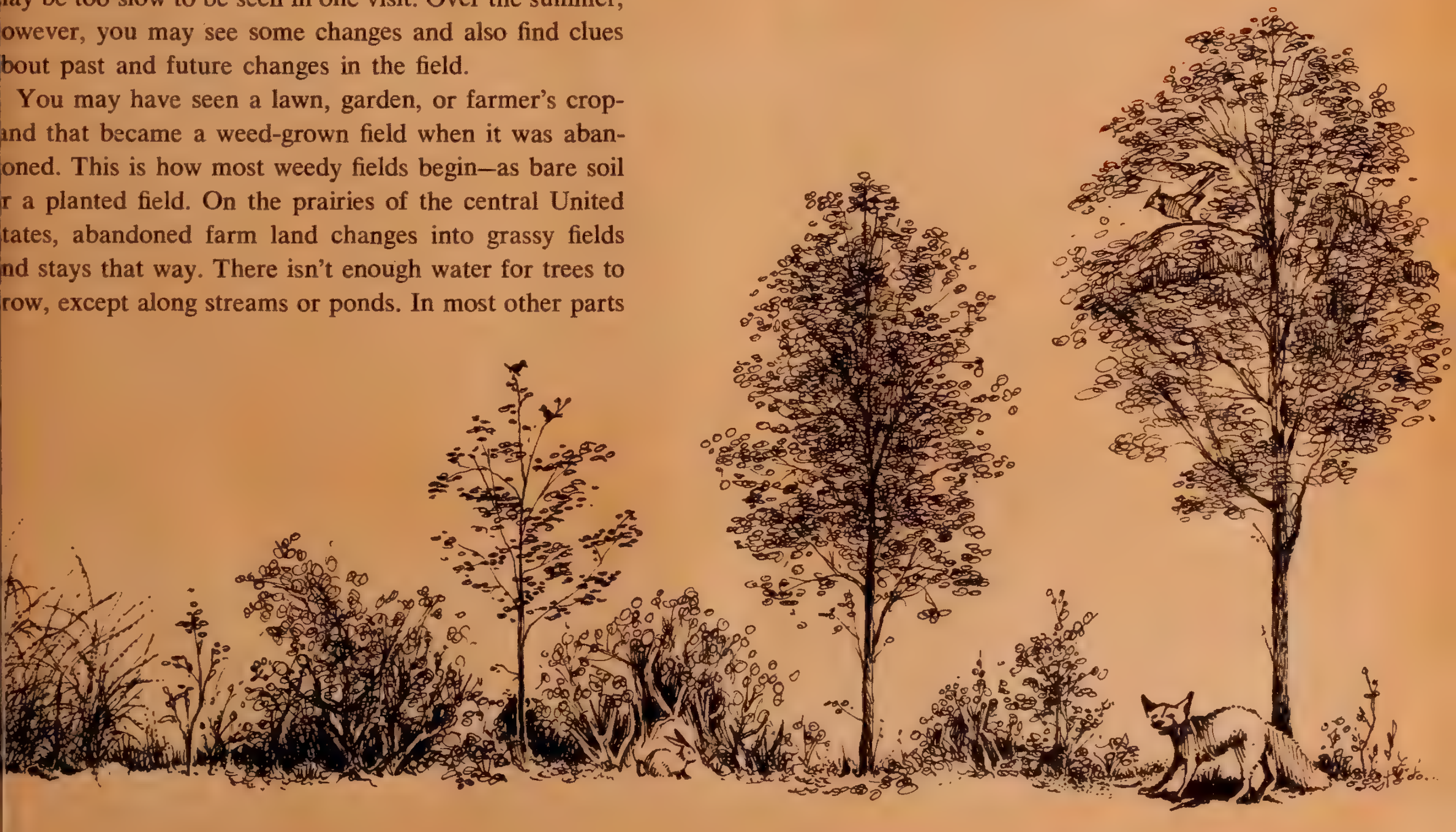
The first plants that grow on an abandoned patch of soil are usually those called *annuals,* which live for just one growing season. They include peppergrass, ragweed, and other kinds of plants that thrive in open, sunny spots. But as the years pass, the annual plants lose their places to others, such as mullein, Queen Anne's lace, and many kinds of grasses. These plants live more than one year and they don't need open, sunny places in which to get started. They crowd out the pioneer plants.

After a few more years the grasses and tall weeds must compete for sunlight, water, and other needs with other plants that spring up—berry bushes, shrubs, quick-growing trees like sumac, and tree seedlings. If the field is undisturbed by man, eventually the trees become so big that

(Continued on the next page)

WHERE DO THE SEEDS COME FROM?

Many of the pioneer plants that spring up in an abandoned field grow from seeds that are carried by the wind. But many seeds are too heavy to be spread by the wind. As you find different kinds of plants growing in a field, try to find out how their seeds got there. How could an oak acorn or berry seed reach the middle of an open field?



their shade keeps many of the smaller plants from getting enough sunlight for life. A forest grows where there was once an open, grassy field *(see diagram on page 3).*

Since these changes take many years, you can't observe them in one field in one summer. But you can probably find some signs of the past and future stages. You may still be able to find parts of a field in the early, annual weed stage. And, while most of the field is filled with grasses and tall weeds, you may find some tree seedlings that will someday grow large and be part of a forest.

See if you can find long-lived weeds that are crowding out the annual kinds *(see "The Unwanted Plants," page 8).* If you find any young trees, notice if their shade has affected the kinds of plants beneath them.

As the plant life of a field slowly changes, the animal life is also affected. Meadow mice *(see photo)* thrive among thick grasses and weeds. When the grasses become sparse, meadow mice can't survive. They may be replaced by deer mice *(see photo).* Meadow larks and killdeer *(see photos)* feed and nest in open fields. Later, when taller

Meadow mice (far left) are common in grassy, weedy fields. They are seldom seen because they are active mostly at night. When the plant life of a field changes to mostly shrubs and trees, mice such as the white-footed or deer mouse (left) become common.

INVESTIGATIONS

HOW VACANT IS A VACANT LOT?

If you live in a city and have no park or other open country nearby, make a survey of the different kinds of plants and animals living in a vacant lot. What sort of plants grow there? What kinds of animals either live in the lot or visit there? Dig into the soil and look for earthworms, sowbugs, and other small animals. (If you would like to study the lives of earthworms, see "Exploring the Earthworm's World," in the April 10, April 24, and May 8, 1967 issues of *N&S*.) By making several visits during the summer (especially at different times of the day), you may discover a surprising amount of life in the midst of the city.

LAYERS OF LIFE

In a forest, certain animals live mostly high in trees, others live in lower trees and shrubs, and still others spend most of their lives on the ground. Find out if there are similar "layers of life" in a field. Watch to see if there are any birds, insects, or spiders that spend most of their time near the tops of plant stems. Do other kinds of animals live mostly on or near the ground?

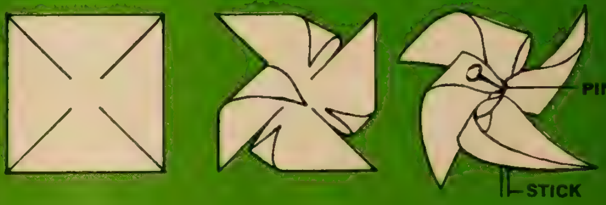
EXPLORE AT NIGHT

Some of the animals living in a field community are active only at night. Ask your parents for permission to explore the field at night. Take along a flashlight and insect repellent. Move slowly and quietly, listening to the night sounds. Try to find night-calling insects and identify them. Are any flying insects attracted to your light? See if you can find insects and other animals by reflections of your light from their eyes. Also look for the wary small mammals, such as shrews and meadow mice, that live in fields.

LITTLE CLIMATES

The animals living in a field don't have the same climate as you do when you walk through a field. For one thing, the air close to the ground contains more water vapor than the air above the plants. The plants give off this water vapor from their leaves.

You might try to find other ways to compare the climate near the base of the grassy jungle with the climate at the tops of the weeds. Make two identical pinwheels *(see diagram).* Put one close to the ground among the plants and the other at the height of the tallest weeds. Compare their spinning on a breezy day. Also use a thermometer to find the temperature at ground level and at weed top level. How does the weedy growth affect the temperature near the ground?

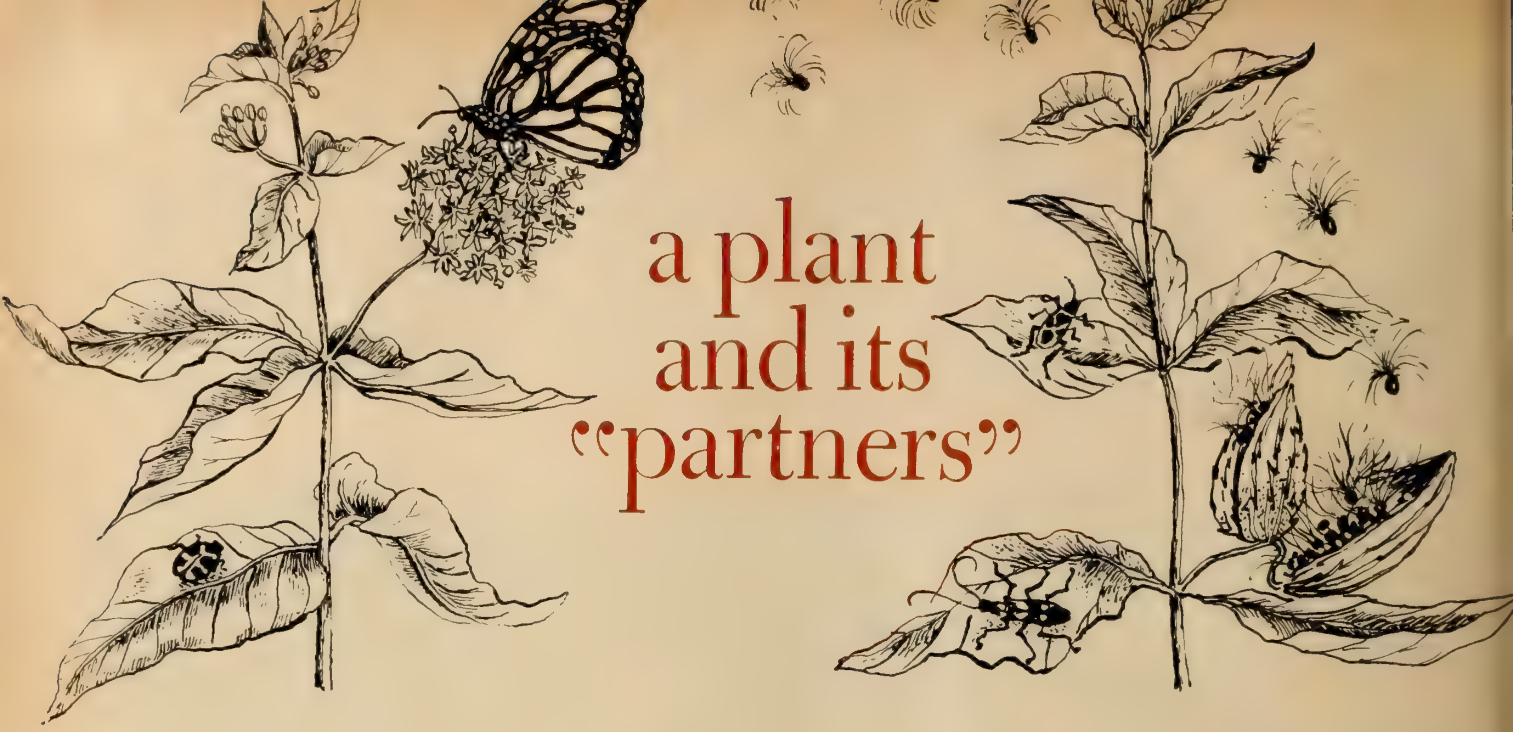


plants take over, these birds no longer find ideal living conditions. Birds such as song sparrows, catbirds, and cardinals live among the shrubs and saplings.

Be sure to record your observations in a notebook. There is still much to be learned about the changes of plant life in an area (called *plant succession*). You might discover something important. Also try to take some photographs of the field as it is today. Keep the photos (and negatives) with your notes. Years from now you can revisit the field and see for yourself how it has changed ■

■ For help in exploring a field, look in a library or bookstore for the following books (and also see the books listed at the end of other articles in this issue). **The First Book of Weeds,** by Barbara Beck (Franklin Watts, Inc., New York, 1963, $2.65) has drawings of about 80 kinds of weeds and tells about their lives. A beginning book about plant succession is: **Birth of a Forest,** by Millicent Selsam, Harper & Row, New York, 1964, $2.95. For help in identifying birds, see field guides such as: **Field Guide to the Birds** (for eastern United States), 1947, and **Field Guide to Western Birds,** 1961, by Roger Tory Peterson, Houghton Mifflin Co., Boston, each $4.95. For help in identifying mammals, see field guides such as: **The Mammal Guide,** by Ralph S. Palmer, Doubleday & Company, Inc., New York, 1954, $4.95.

These photos show some of the animals you may find living in fields. The garter snake (1) may even be found living in vacant lots of cities. Woodchucks (2) are wary rodents that live on farms, along roads, and in suburban fields. You may find meadowlarks (5) in the same sort of fields where woodchucks live. Killdeer (3) nest and feed in fields that have little or no plant growth, while moles (4) can be found in underground burrows in many kinds of fields, including lawns.



a plant and its "partners"

■ It is not surprising to find an animal that depends on plants for its food. But you can sometimes find certain animals that depend on *a particular kind* of plant for life. This summer you can have some fun with these special plants by watching to see how many different kinds of animals live on or in them.

A good plant to observe is *milkweed*. You can find this tall plant (two to five feet high) growing in fields, meadows, and along roads almost everywhere in North America. Once you locate a milkweed patch, you can begin to study the life in, on, and around the plants.

Pay special attention to the flowers (*see diagram at left*). They attract many insects. Their colors and strong odor lure butterflies, moths, bees, and other flying insects. As an insect crawls among the flowers after nectar, one of its legs may get caught in a tiny slit in a flower. If the insect is small, it may be stuck there and die. You may see some of these. Larger insects, however, usually pull free. When they do this, they break away a part of the flower that contains grains of pollen. Then, when the insect flies to another milkweed flower, it carries the pollen along (*see "How Plants Reproduce,"* N&S, *March 27, 1967*).

Mystery of the Orange Insects

Of all the milkweed insects, the best known is the monarch butterfly. This bright orange and black butterfly lays its eggs on the underside of milkweed leaves. After three or four days, a tiny caterpillar (*larva*) emerges from the egg and begins to feed on the leaves. Later the caterpillar leaves the plant and develops into a *chrysalis,* from which the adult butterfly eventually hatches.

The monarch is not the only milkweed insect with bright colors. You may find beetles and bugs with orange and black markings. Now the monarch isn't eaten by birds and other animals; its bright color seems to be a warning that it doesn't taste good. Is the same true of the bright-colored beetles and bugs? No one knows.

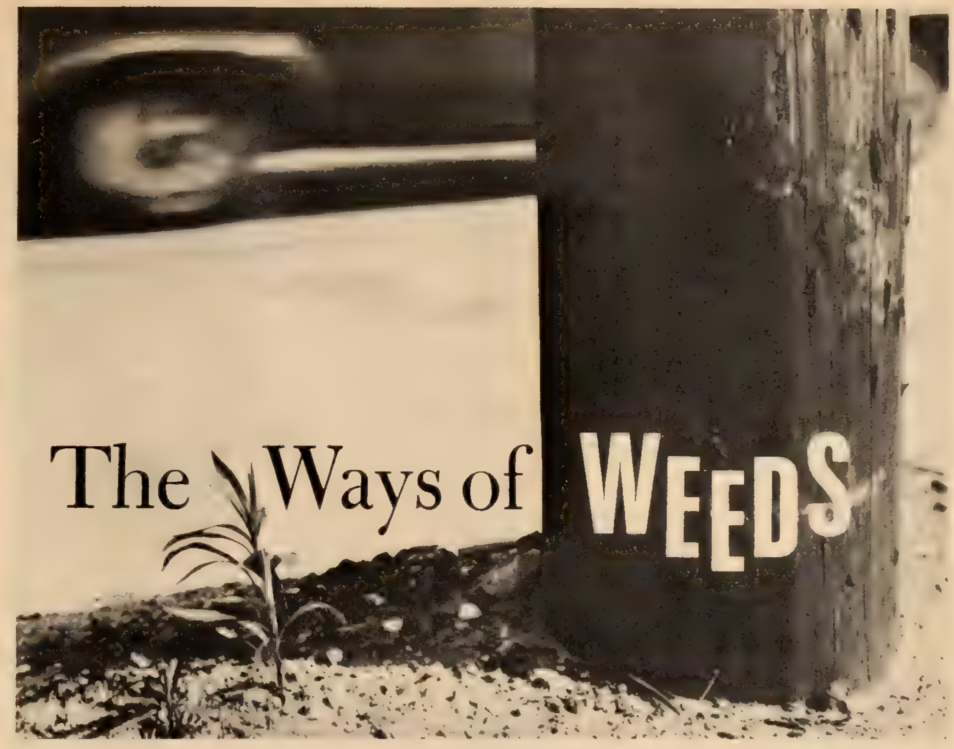
The milky juice of milkweed plants contains chemicals that can be poisonous to mammals, birds, and other animals. Is it these chemicals that make monarchs bad-tasting? Again, no one knows.

Not all insects living on milkweeds are brightly-colored. Green aphids (*see page 12*) suck juices from the plant. (Whether chemicals in the juices affect the taste of aphids is not known.) Midges lay their eggs inside milkweed stems and leaves, and their larvae develop there. Wasps visit milkweed plants regularly, not to feed on the plant, but to catch some of the other insects there (*see "The Secret Lives of Wasps and Bees,"* N&S, *April 24, 1967*).

Still other animals probably eat milkweed seeds. The seeds develop in a pod that breaks open in the fall, gradually releasing hundreds of small seeds that have fluffy parachutes (*see diagram at right*). While the seeds are still attached to the pod, you can watch to see if any birds, mice, insects, or other animals feed on them. Once the seeds break free from their pods, the wind carries them away.

The milkweed is just one kind of field plant that has different kinds of insects, spiders, and other animals depending on it. You might try observing other kinds of plants, such as goldenrod and thistle. Whatever plant you pick, try to find a growth of it close to where you live. Then you can visit it frequently, increasing your chances of discovering new things about the plant and its animal life.—LAURENCE PRINGLE

The Ways of WEEDS



This weed is growing in poor soil, surrounded by concrete, in air containing automobile fumes. Like all weeds, it can survive where other kinds of plants would die.

■ There are no weeds in nature!

In nature there are different kinds of plants and animals, but no one kind *(species)* is of any greater value than any other. "Value" and "importance" are terms used by humans and have meaning only to us.

What, then, are weeds? Weeds are plants that we don't want to grow in places where we *do* want other plants to grow. We don't *cultivate* weeds, or plant and water them, as we do grass or plants in a flower or vegetable garden. Yet the weedy plant often grows exactly where we don't want it—on the lawn or among our cultivated plants.

Not only do weeds grow where they are not wanted, but they usually succeed in growing *better* than the species cultivated by man. Weeds are among the most vigorous species of plants. They can survive a drought that kills cultivated plants, and they thrive in open places with plenty of sunlight. This means that the farmer, with his open sunlit fields, finds weeds one of his greatest headaches.

The seeds of most weedy plants are long lived. The seeds of mullein, for example, can sprout after 80 years and probably longer. Weeds also grow faster and taller than cultivated species, which are soon blocked from direct sunlight. It is no wonder that the gardener, farmer, or lawn keeper dislikes them.

Why Weeds Succeed

The common kinds of weed do not belong to any one family of plants; just about every major group of flowering plants contains weed species *(see next page)*. However, many common weeds belong to the families of flowering plants that have evolved most recently, such as the grasses, mints, and composites (which include daisies, asters, and sunflowers). Members of these plant families can grow well in places where the conditions—of soil, moisture, and so on—are quite different. They produce many seeds and have ways of scattering the seeds far and wide.

Weeds also have a number of ways of spreading without seeds. Some weeds, for example, produce a *rhizome*—an underground, horizontal stem. The rhizome grows rapidly and sends up aerial shoots as it grows.

There are weed trees, shrubs, and herbs. Many weeds are *perennial;* they live for many years, and each year shed seeds. Many other weeds are *biennials,* which live for two years. During the first year they produce roots, stems, leaves, and during the second year they send up flowering stems and produce seeds. A number of other weeds are *annuals,* which live for one year. These plants grow from seeds, flower, produce seeds, and scatter them—all in the short space of one growing season.

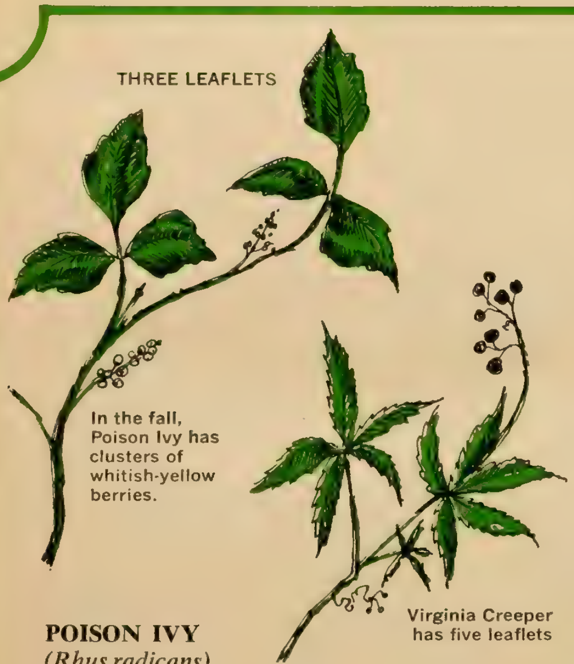
Well over half of our common weeds were not growing in North America when the first colonists arrived from Europe. The early settlers brought weeds to America, sometimes on purpose, sometimes by accident. Weeds arrived from Europe in the ballast (such as rocks or gravel) that was used as weight in the holds of colonial ships. Some weed seeds probably arrived among the seeds of corn and other crop plants brought from Europe.

As the forests fell before the colonial axe, as roads were cut through the wilderness and the prairie schooner traveled them, and as the roadbeds for railways spread across America, weed plants soon sprang up in these open, sunny areas. Weeds marched across the land hard upon the colonists' heels.—LAWRENCE J. CROCKETT

THE "UNWANTED" PLANTS

■ How many different kinds of weeds can you find in your neighborhood this summer? Weeds grow everywhere you go—from city sidewalks to country roadsides. The drawings on these pages will help you recognize 10 of the most common weeds in North America; the captions tell something about the lives of these plants and why they are so successful.

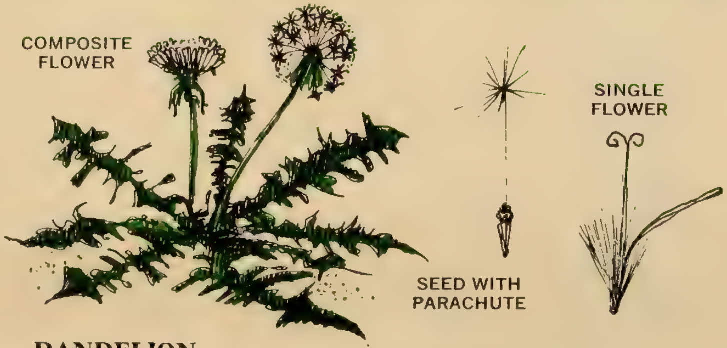
—LAWRENCE J. CROCKETT


THREE LEAFLETS
In the fall, Poison Ivy has clusters of whitish-yellow berries.
Virginia Creeper has five leaflets

POISON IVY
(Rhus radicans)

This plant is poisonous to touch. To some people it is poisonous even to be near. Poison ivy is a vine with leaves that grow on alternate sides of its stem. Each leaf is made up of three shiny leaflets, toothed along their edges. The shiny material is the poisonous chemical urushiol, which causes painful blistering of the skin. Do not confuse this dangerous plant with the harmless and attractive vine called Virginia creeper. Its leaves are not shiny and each has *five* leaflets.

FLOWERING STALKS

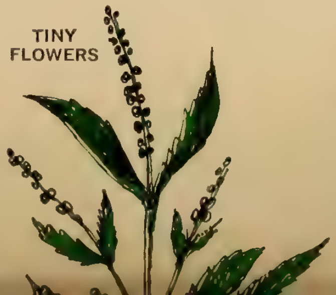

COMPOSITE FLOWER
SINGLE FLOWER
SEED WITH PARACHUTE

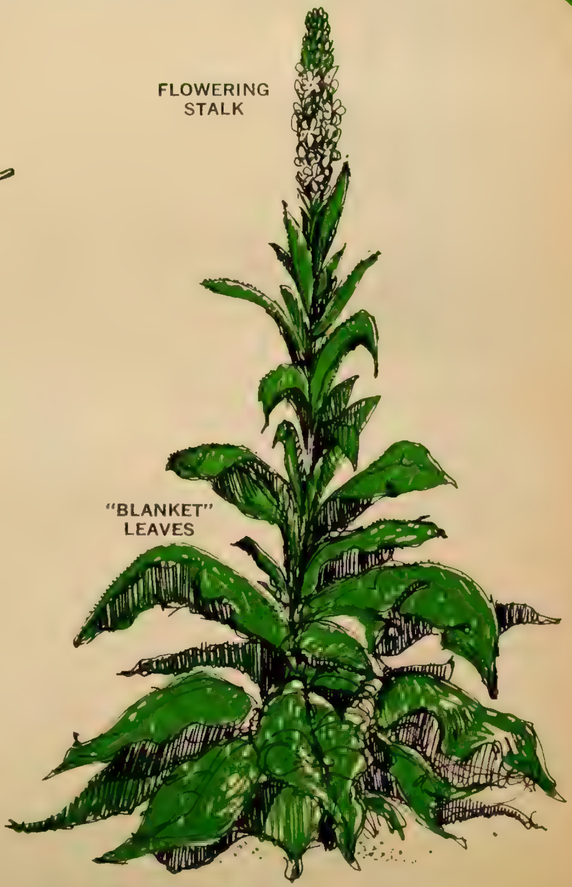
DANDELION
(Taraxacum officinale)

The dandelion's rosette of leaves is made up of many deeply-lobed leaves. They are edible when young, and can be cooked or used in salads. The thin, hollow, pale green stalks are topped by dense clusters of flowers. The cluster is so dense that it seems to be a single flower. Pick a dandelion and pull it apart. How many individual flowers do you find? Each is an entire flower. (A "flower" composed of many individual flowers is called a *composite.*) Usually each of these tiny flowers produces a seed, which is attached to a delicate parachute that helps the wind carry the seed away from the parent plant. A single dandelion plant blooms from May to October, producing thousands of seeds.

GIANT RAGWEED
(Ambrosia trifida)

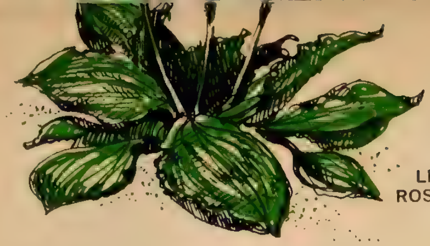
This annual plant may grow 15 feet high! Its rough-hairy leaves have three to five lobes. You may find leaves a foot long on the taller plants. Ragweed's tiny, greenish flowers


TINY FLOWERS


FLOWERING STALK
"BLANKET" LEAVES

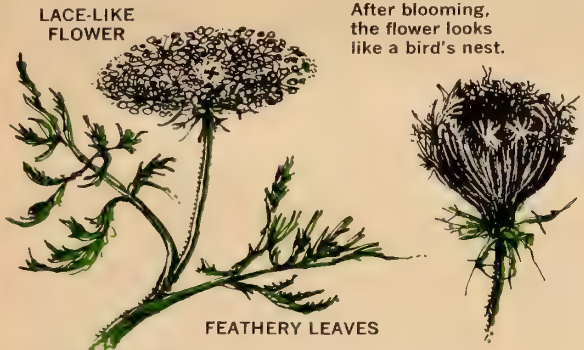
GREAT MULLEIN
(Verbascum thapsus)

Great mullein is also called, and for good reason, "blanket leaf." Its large leaves are covered



BROAD-LEAVED PLANTAIN
(Plantago major)

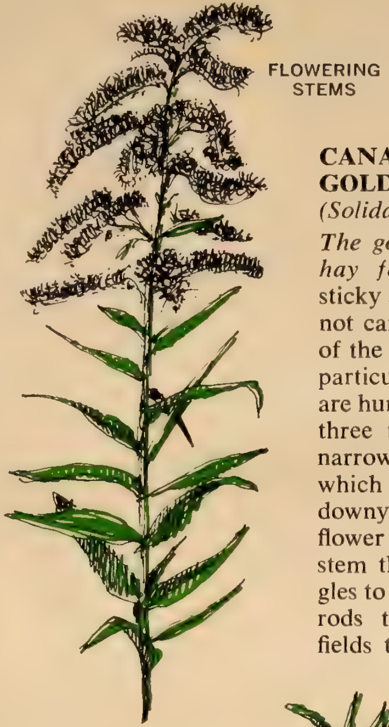
This common weed of poorly kept lawns has a tap root topped with a *rosette* (circle) of large rounded leaves with easily seen, depressed veins. The tiny, pinkish flowers grow on long, thin stalks, from their tops to about one inch above the ground. The circle of leaves shades out grass beneath. Each of the many flowers produces many seeds, helping to spread this weed far and wide. The broad-leaved plantain came with colonists from Europe.



WILD CARROT OR QUEEN ANNE'S LACE
(Daucus carota)

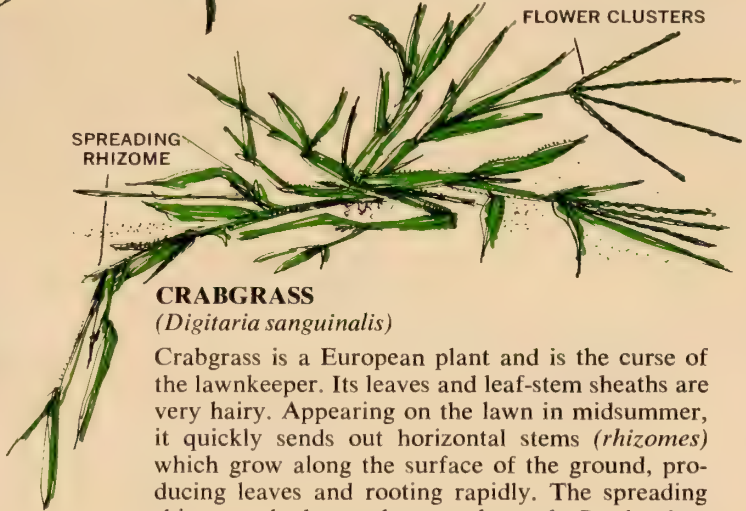
The leaves of this biennial look lacy or feathery (much more feathery than those of the common ragweed). The great number of tiny white flowers in little clusters (called *umbels*) form a large cluster that looks like lace. At the center of this large flower cluster (four or five inches across) you can find a single black or purple flower. Crush a leaf and notice the pungent and somewhat unpleasant odor. Other members of the carrot family also produce strong odors. After this plant's flowers have produced seeds, each tiny flower bends inward on its stalk, giving the whole flower cluster the appearance of a bird's nest. This accounts for the third common name for this weed, bird's nest weed.

ried away by the wind. It is this pollen that is one of the main causes of hay fever.



CANADIAN GOLDENROD
(Solidago canadensis)

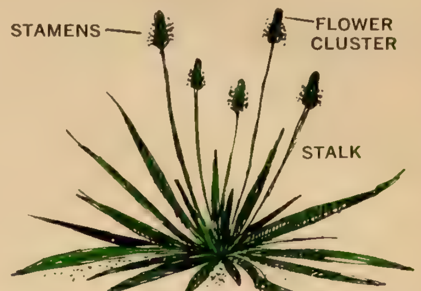
The goldenrods do not cause hay fever! Their pollen is sticky and is spread by insects, not carried by air to the nose of the hay fever sufferer. This particular goldenrod (there are hundreds of species) grows three to six feet tall. It has narrow, lance-shaped leaves which are smooth above and downy beneath. The golden flower clusters grow along a stem that is held at right angles to the main stem. Goldenrods thrive in sunny, open fields that are not cultivated.



CRABGRASS
(Digitaria sanguinalis)

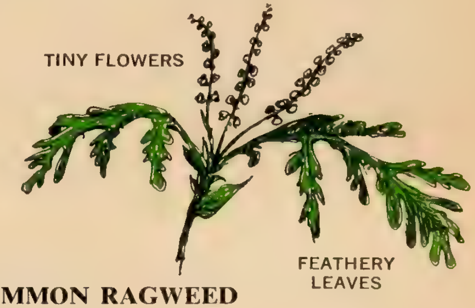
Crabgrass is a European plant and is the curse of the lawnkeeper. Its leaves and leaf-stem sheaths are very hairy. Appearing on the lawn in midsummer, it quickly sends out horizontal stems *(rhizomes)* which grow along the surface of the ground, producing leaves and rooting rapidly. The spreading rhizomes shade out the grass beneath. By the time this lawn invader dies with the first frost it has killed your grass and left ample seed to give you more trouble next year.

bearing stem. The stem is covered with bright yellow flowers which first open three quarters of the way up the stem. The last flowers to open are at the top of the stem, which may reach a height of 10 feet.



ENGLISH PLANTAIN OR RIB GRASS
(Plantago lanceolata)

This plantain also has a rosette of leaves but each leaf is much thinner than those of its cousin. The thin, dark green leaves are deeply veined (hence the name rib grass). Its 6-to-10-inch long flowering stalks end in stubby clusters of flowers. When the pollen-producing stamens are mature they look like pins stuck in a cushion *(see diagram)*. Rib grass is a vigorous seed producer and a threat to a handsome lawn.



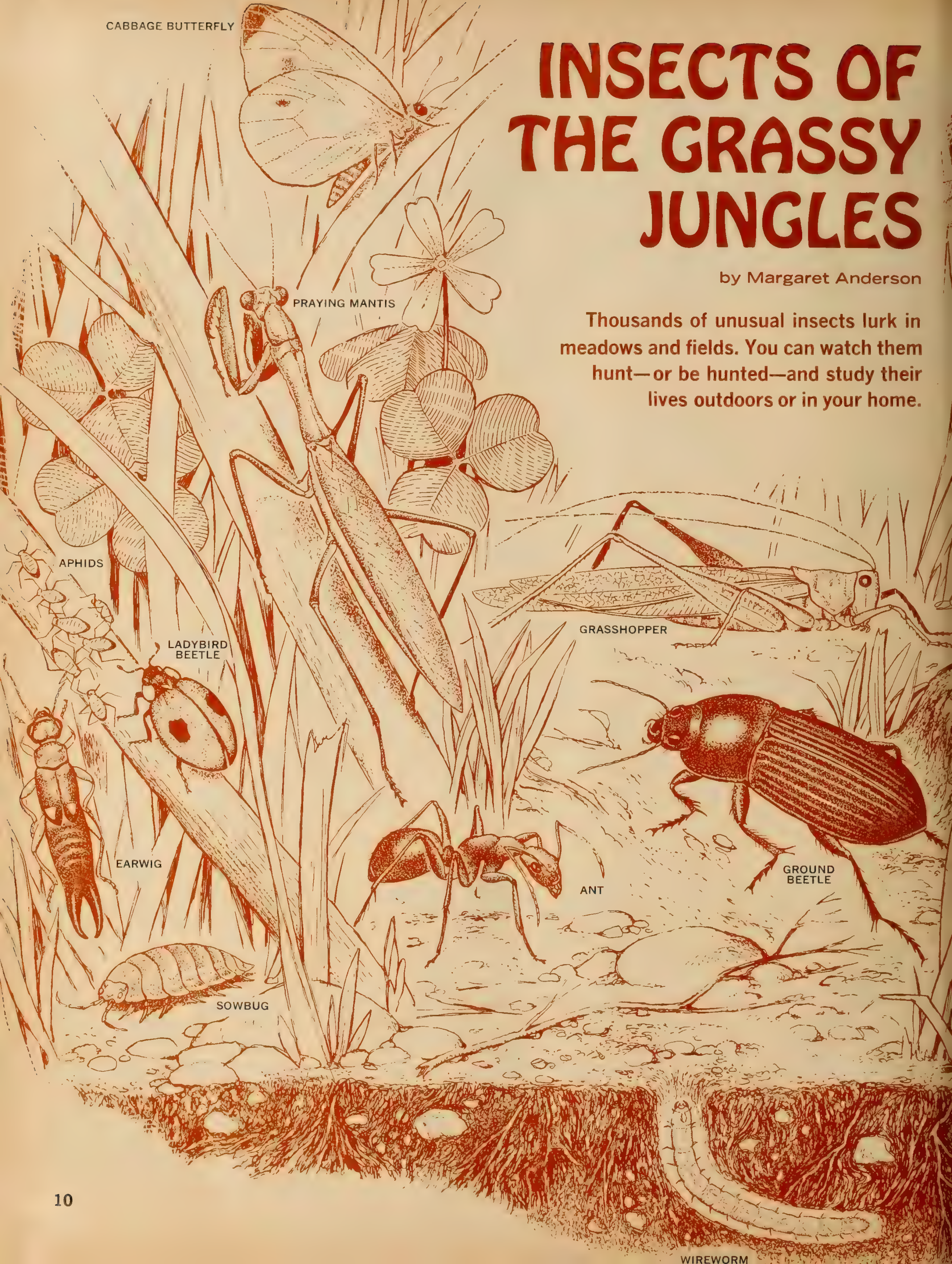
COMMON RAGWEED
(Ambrosia artemsiifolia)

Common ragweed is the giant ragweed's cousin and one of the most common of all weeds. It may grow to be five feet tall, and has leaves that are only two to five inches long, but it produces much more pollen than its taller cousin and is a great nuisance to hay fever sufferers. The leaves of this ragweed are easily told from those of the giant ragweed; they have a lacy or feathery appearance. Both ragweeds bloom from July to October. Both produce many seeds.

INSECTS OF THE GRASSY JUNGLES

by Margaret Anderson

Thousands of unusual insects lurk in meadows and fields. You can watch them hunt—or be hunted—and study their lives outdoors or in your home.


CABBAGE BUTTERFLY
PRAYING MANTIS
APHIDS
LADYBIRD BEETLE
GRASSHOPPER
EARWIG
ANT
GROUND BEETLE
SOWBUG
WIREWORM

■ At first glance, you may not see any life in a vacant lot or field. By getting down on your hands and knees and looking among the plants, however, you'll find lots of life. You'll find death too, for the many kinds of insects living in fields can be divided into two groups—the hunted and the hunters. You may actually see one kind of insect hunting and killing another.

To study the lives of common field insects, you need a hand lens (or magnifying glass), a notebook and pen, some empty jars, and a trowel. You should also have a book to help you identify insects (*see list at end of article*).

I can suggest some of the insects to look for, but what you find is going to depend on where you live and the type of plants growing in your neighborhood. Wherever you live I'm sure there will be insects eating the plants and other insects eating those insects.

Introduction to the Plant Eaters

To get to know the plant eaters, look for damage to leaves. On some leaves you will find blotches or winding lines. If you hold one of these leaves up to the light you may see a worm-like larva tunneling its way through the leaf. This is a leaf miner. It spends its larval life between the top and bottom surface of the leaf—a rather narrow home!

There are many leaf miners. Some are the larvae of moths and some of flies. If you find a leaf with a pupa (usually inside a small "blister"), put the leaf in a jar until an adult insect emerges from the pupa. Use a magnifying glass or hand lens to see the moth or fly that comes out; they are mostly very small.

Also, look for the sap suckers. The commonest of these are aphids. Sap suckers have mouth parts that pierce the leaves to suck the sap. This injures the leaves. The feeding of aphids causes many changes in a plant, such as rolled or blotched leaves.

Dig into the soil and you may find some of the root feeders. The wireworms (*see diagram*) are among the most destructive. They are larvae that develop into click beetles. Most of the root feeders are the larvae of beetles and flies.

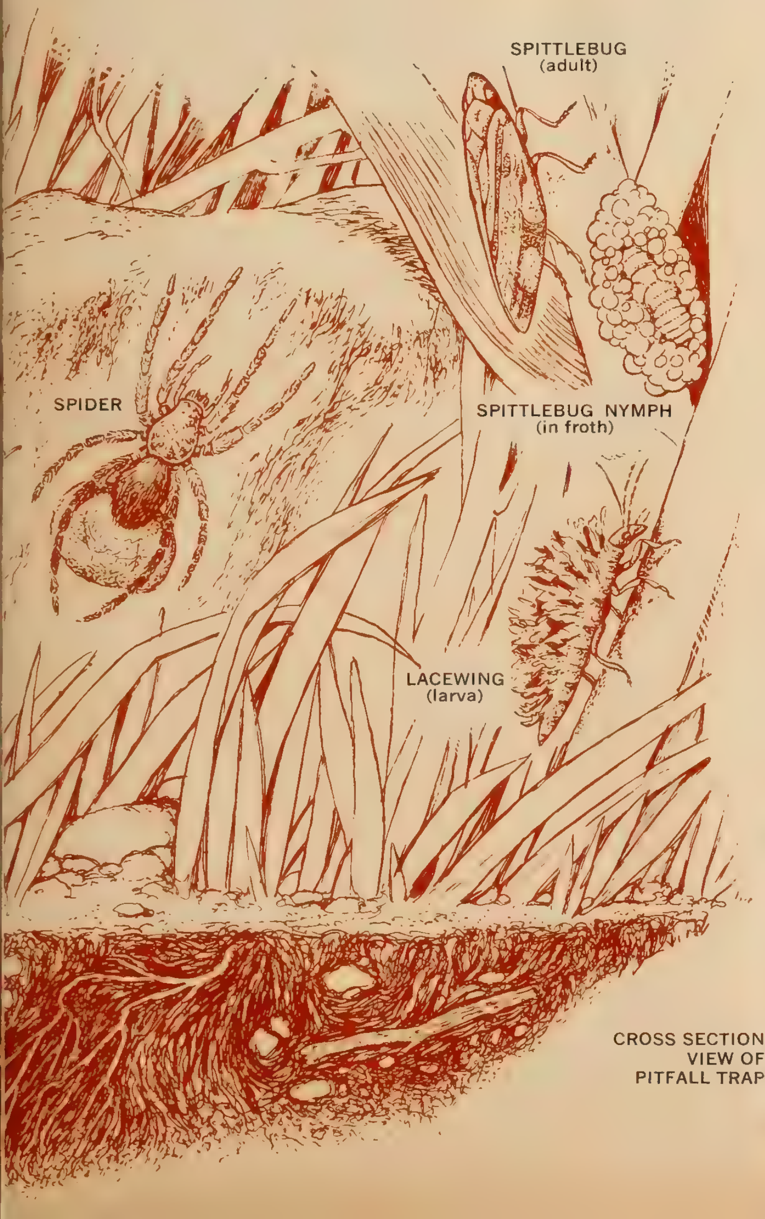
You may find many other kinds of plant-eating insects, including grasshoppers. Watch especially for spittlebugs (*see diagram*) which often live on grasses and alfalfa. The young (called *nymphs*) produce a froth from their bodies that completely surrounds them. This froth seems to protect the insects from their enemies and also provides the moist environment they need for life. (Take a spittlebug from its froth and set it on a grass stem. Then see how long it takes for the insect to produce a new "house" of froth.)

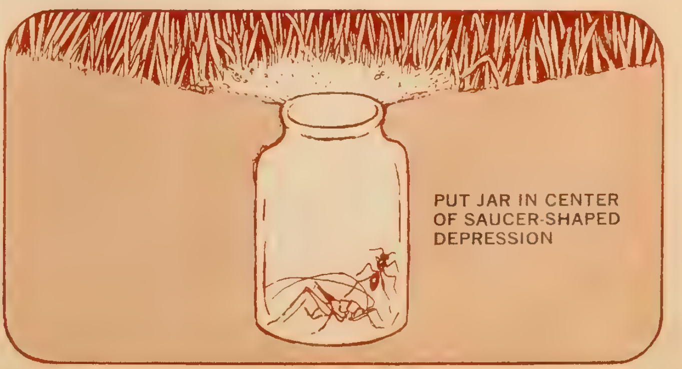
The Hunters

The insect eaters, or *predators,* are often fast runners with alert senses. An example is the ground beetle. It has long legs, long antennae, large eyes, and big powerful jaws. As you'd guess from its name, it is a ground dweller and eats soil insects.

A good way to get to know the ground beetles is by setting *pitfall* traps. These are just jars sunk into the ground (*see diagram*). The beetle falls in and can't climb out. Be sure that the rims of the jars are level with, or below, the surface of the ground. If you can set the jars in the middle of saucer-shaped depressions so much the better.

(Continued on the next page)





CROSS SECTION
VIEW OF
PITFALL TRAP

Using nothing more than a half dozen empty jars, you can find out a lot about the habits of insect ground predators. Put the jars in different kinds of areas—in a lawn, under a tree, in tall weeds, in a garden. I found that the busiest place in my garden was beside some boards that were rotting in a corner.

Empty the jars each morning and evening, and keep a separate record for each jar. From your results can you find one area where beetles are most abundant? Would you say they are more active during the day or night? How are they affected by the temperature and weather?

Besides beetles, you will catch other kinds of insects (such as ants and earwigs) and animals such as spiders and sowbugs (which are not insects). Sowbugs and earwigs are not predators but are *scavengers*— garbage disposals.

An easily recognized beetle you may see is the ladybird or ladybug beetle. These insects aren't swift, long-legged creatures like the ground beetles. They live almost entirely on aphids, which are easy to catch and eat. Ladybug eggs are sometimes laid in the middle of a promising aphid colony. When the young hatch they find a meal waiting for them.

Another aphid eater is the lace-wing, a delicate, pale-green insect with large, transparent wings. The larvae of some species carry debris on their backs as a kind of camouflage. The debris is made up mostly of skins of its victims. If you find one of these lacewing larvae *(see diagram),* carefully strip off the debris and you will see there are rows of hooked bristles on the body segments to hold the covering. Put the larva and the debris in a small jar and watch to see how it replaces the pieces.

The hover-fly also lays its eggs in aphid colonies. The larva, a slug-like creature, sucks out the inside of the aphid, leaving only the dry skin.

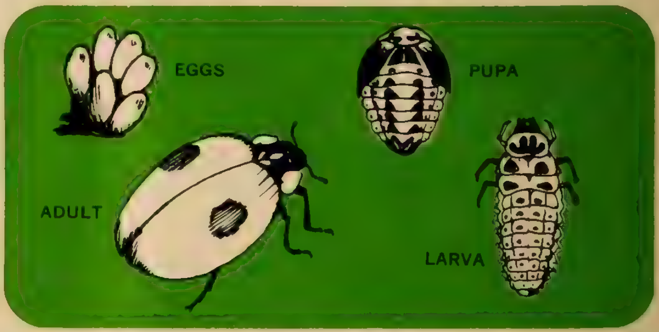
It sounds as if the aphids have a bad time of it. But aphids reproduce at a tremendous rate. Someone has figured that, starting with one female, there could result *822 tons* of aphids in 18 weeks! This shows why we need predators such as ladybirds, lace-wings, and hover-flies.

How Much Does a Ladybird Eat?

There are some investigations you can do to find out just how helpful these predators are. For example, you can try to find out how many aphids a ladybird will eat in a day. Put a ladybird in a small jar or bottle and put in a little moist paper towel to keep the air humid. Then take a leaf and use a fine brush to knock off all but 10 aphids. Put the leaf with its aphids in the jar. Next day, take out the leaf and see how many aphids have been eaten. (Be careful not to count any shed skins as dead aphids.) Then put in a fresh leaf with 10 more aphids. If your ladybird always eats all 10 aphids, try offering more.

You can also try feeding the larvae of ladybirds (*see diagram*). One thing to notice is that a larva that is about to shed its skin stops eating for a while. This happens, too, before it forms a pupa (*see diagram*). Look for a very young larva—or better still, eggs—and see if you can find out how many aphids a ladybird beetle eats during its larval stages.

Another experiment you can try is to find out what happens to a larva that gets barely enough to eat. When you know how many aphids a larva will eat, then you can figure out a starvation diet. Will this result in an undersized adult, or will it just take a longer time to produce a regular sized adult?

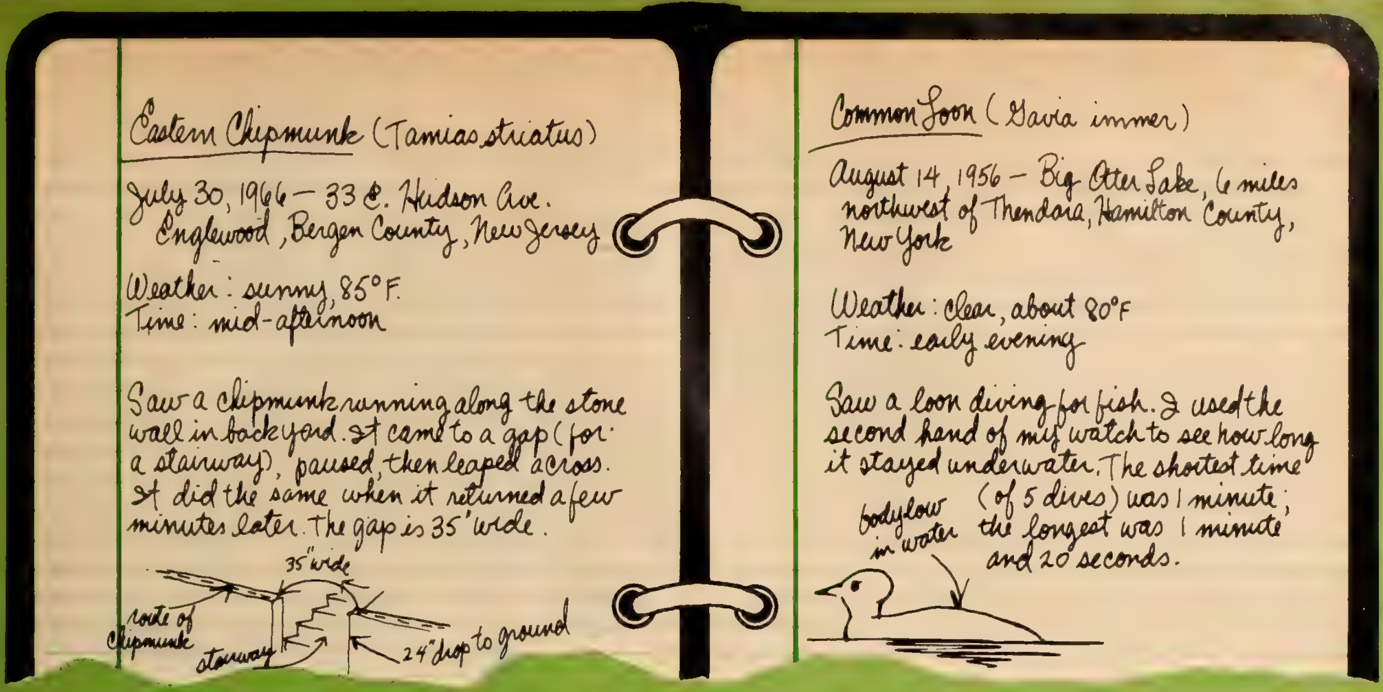


Ladybird beetles (above) and many other insects go through these four stages of development during their lives. Other kinds of insects, such as grasshoppers and spittlebugs, have just three stages—egg, nymph, and adult.

When working with aphids you are sure to come across some dead, but not shriveled, aphids. They are usually light brown and are stuck to the leaf. These have been attacked by parasites and are called *mummies*. If there is a small hole in the aphid, then the parasite has emerged. If there is no hole, put the aphid in a jar and wait for the tiny wasp to come out. Like the predators, these parasites help control the number of aphids.

When doing these investigations, keep asking yourself questions; then try to find ways to answer them. (Remember that to be sure of your answer you should repeat an experiment several times.) Even in a small field or lot, there are enough insects, spiders, and other small animals to study all summer long ■

🟩 Some good books that will help you identify insects are: **Field Book of Insects,** by Frank E. Lutz, G. P. Putnam's Sons, New York, 1935, $3.95: **Insects,** by Herbert Zim and Clarence Cottam, Golden Press, New York, 1956, $1 (paper). Books that tell how to study and collect insects include: **The Bug Club Book,** by Gladys Conklin, Holiday House, New York, 1966, $2.95; **Field Book of Nature Activities and Conservation,** by William Hillcourt, G. P. Putnam's Sons, New York, 1961, $4.95.



Eastern Chipmunk (Tamias striatus)

July 30, 1966 – 33 E. Hudson Ave.
Englewood, Bergen County, New Jersey

Weather: sunny, 85°F.
Time: mid-afternoon

Saw a chipmunk running along the stone wall in back yard. It came to a gap (for a stairway), paused, then leaped across. It did the same when it returned a few minutes later. The gap is 35" wide.

35" wide
route of Chipmunk
stairway
24" drop to ground

Common Loon (Gavia immer)

August 14, 1956 – Big Otter Lake, 6 miles northwest of Thendara, Hamilton County, New York

Weather: clear, about 80°F
Time: early evening

Saw a loon diving for fish. I used the second hand of my watch to see how long it stayed underwater. The shortest time (of 5 dives) was 1 minute; the longest was 1 minute and 20 seconds.

keeping a field journal

■ Several years ago, I found the nest of a screech owl in a hollow tree. Recently I've been tempted to go back to the tree and take pictures, if owls still nest there. But where is the tree? I don't remember and didn't take any notes. The tree–and its owls–are lost to me forever.

You may have had the same thing happen to you. An event is fresh in your mind and you think that you'll never forget it. But months or years later you discover that you have forgotten important details.

To keep this from happening, you should keep a notebook (usually called a *journal*) just as many scientists do. As time goes by you'll find that the information "stored" in your journal becomes more and more valuable.

The journal itself doesn't have to be fancy. A loose-leaf notebook (about 6 by 9 inches) is best, and you should write your records in ink, not pencil. In one part of your journal you might keep notes that briefly describe the events on a hike or trip. Then on other pages you can keep more detailed notes on certain animals, plants, or other things that interest you *(see the samples above).*

Here are some tips on the sort of information you should put in your journal to make your findings as accurate and valuable as possible.

DATE: When do migrating birds return to your neighborhood? About what time can you expect to find certain wildflowers in bloom? By keeping notes on these events—and recording the date–your journal will help you predict such events in the future.

TIME: The time of day when you see something also may be important. Animals are more active at some times than at others. You should also take notes on the timing of certain events. For example, how often does a robin bring food to its young? How often does your pet snake eat?

WEATHER: Just as your activities are affected by the weather, so are the activities of other animals and of plants. Keep notes on the temperature, clouds, rain, snow, wind conditions, and so on. With good records, you may be able to predict how certain animals and plants are affected by the weather. You might also try to predict the weather by observing changes in the kinds of clouds.

LOCATION: Don't overlook this "obvious" fact. Always record the state, county, and nearest city or town. "In the back yard" is not accurate enough, since you may move and might not be able to remember *which* back yard you meant. Even scientists sometimes find that they have not been specific enough about the location of something. When Charles Darwin was collecting finches in the Galapagos Islands, he just put the location "Galapagos Islands" on the birds' labels. Later he discovered that there were different kinds of finches on the different islands of the Galapagos group (*see "From 'Blobs' to Lions," N&S. March 27, 1967*). From then on Darwin kept better records.

DESCRIPTION: Most people who keep journals regret that they didn't take more notes; they never feel that they've taken too many. What seems like an unimportant detail may be important later. You should jot down your notes as soon as possible after observing something. Use rough sketches, maps, or any other aid that will help you keep your notes accurate and complete. The samples shown on this page will help you get started.

—LAURENCE PRINGLE

A SNAKE FOR A PET

by Kenneth Bobrowsky

Even if you live in a city, you can probably find some harmless snakes in a park or nearby vacant lot. Here is how to catch and keep a snake for a while to learn about its life.

To hold a snake properly, support the weight of its body in your hands and do not squeeze it tightly.

■ Have you ever had a snake as a pet? If you have, you are already one of many people who find these unusual animals fascinating to watch and study. If you haven't, perhaps you are curious about them and would like to keep one for a while.

The number of snakes living near towns and cities has been greatly reduced because their natural living areas have been destroyed or disturbed. But some species such as the common garter snake in eastern North America and the plains garter snake in the midwest may be common in backyards and in vacant lots. They even turn up in small vacant lots in the largest cities. If you search carefully you may find some snakes near your home or in a nearby park.

Snakes are often hard to find even when they are plentiful. The small secretive kinds often live almost under the very noses of people. I recently discovered over 35 small DeKay's snakes under flat boards and old newspapers in a vacant lot in New York City. I found them in a space 12 feet long by 7 feet wide. Later I asked people living nearby if they had ever seen a snake. They said that they had, but only in a zoo.

Where To Find Snakes

Some of what might seem to be the most unlikely places to look for snakes are often the best. Good places to investigate include vacant lots with rubbish, stone walls and fence rows, and abandoned fields. In these areas there are places for snakes to hide and good sources of food. The best place to begin your search is under flat objects resting on the surface of the ground, such as boards, flat stones, and logs.

A garden cultivator with three metal *tines,* or prongs, is a useful tool to use in turning over boards and logs.

INVESTIGATIONS

Many questions about snakes remain unanswered. Through your study you may be able to discover some important information about the lives of snakes. Here are some things you can observe and take notes on:

- When and how often does your snake shed its skin?
- What type of food does it eat?
- How often does it feed? How much does it eat at one time?
- Keep records on its growth and weight over a period of time. How fast does it grow?
- Describe any courtship behavior you see. Does the snake lay eggs or produce living young? What is the size and number of eggs laid? What is the size and number of living young produced? How long does the egg tooth stay on the snout of a young snake after it escapes from its egg shell?
- Is there anything unusual about your snake—its color, its body structure, its habits?
- Under what conditions did you find your snake? When you find a snake, keep notes on the date, place, time of day, weather, and other conditions (see *"Keeping a Field Journal," page 13*).

Always replace the shelter in its original position after lifting it so that animals in the area may use it again.

Many experienced snake collectors make a sort of "snake trap" by placing flat objects in open fields or other places where snakes might live. You might try this too. Visit the board or other object each day to see if snakes have found shelter underneath.

Before you begin your collecting, be sure to check a field guide on snakes. You should be able to recognize the two main groups of poisonous snakes found within the United States. Snakes in the "pit viper" group include the rattlesnakes, copperheads, and water moccasins. Two kinds of coral snake make up the second group. *Under no conditions should you try to catch or keep a poisonous snake.* It is not only dangerous but it is against the law in many places to keep a poisonous snake in your home.

However, try not to confuse harmless snakes with poisonous ones. Harmless water snakes are often mistaken for the poisonous water moccasin that is found in southern states, northward to southern Illinois. A good rule is never to collect a snake unless you definitely know that it is not dangerous.

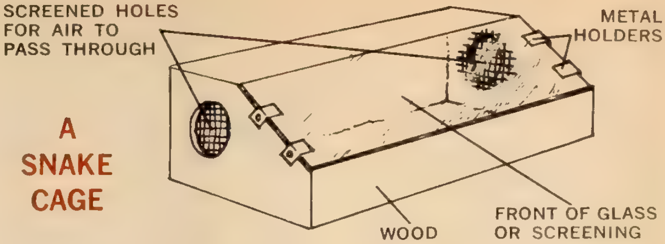
Catching Snakes and Caring for Them

The best way to catch snakes is with your hands. Since harmless snakes (non-poisonous) may bite when first captured, you should wear a pair of leather gloves. After a few days in captivity, most snakes get used to being handled and even seem to enjoy being picked up.

The most important piece of equipment you will need is a few cloth bags in which to carry your catch. Flour and sugar sacks are good for this purpose but first be sure they have no holes. You can also use pillow cases. Air passes freely through these bags, so the snakes can breathe inside. A string sewed at one end can be used to tie the end when closed.

FOOD EATEN BY SOME COMMON SNAKES

SNAKE	FOOD
garter and ribbon snakes	small frogs, salamanders, small fish, tadpoles, and earthworms
DeKay's snake or brown snake	earthworms, slugs
water snakes	fish, frogs, tadpoles
black snakes, corn snakes, bull snakes, rat snakes	mice, other small rodents, occasional small birds
king snakes, indigo snakes	mice, other rodents, other snakes
green snakes	crickets, grasshoppers, other insects



A SNAKE CAGE

SCREENED HOLES FOR AIR TO PASS THROUGH
METAL HOLDERS
WOOD
FRONT OF GLASS OR SCREENING

Before catching a snake, you should have a proper home ready for it. You can make a cage or cages from many different materials (*see diagram*). One easy way to make a cage is to get a screen top for an old aquarium tank. Before placing your snake in its cage, check to make sure that the container is free of cracks and that the lid is securely fastened to the cage.

Put some fine sand or gravel with a few small rocks or twigs on the floor of the cage. In most cases it is best to keep the inside of the cage dry at all times. Snakes may get skin diseases if the cage floor is kept wet. Since snakes drink water, put a small open dish in a corner of the cage and keep it filled.

Many scientists regard snakes as among the cleanest animals in the world. To help them keep clean in a confined cage, be sure to remove any wastes that accumulate.

Snakes may die within 10 or 15 minutes if forced to remain in the direct rays of the sun. For this reason, keep your cage in a place where it won't get much direct sunlight.

Many species of snakes feed on only one kind of food (*see table*). They refuse to eat anything else. When you capture a snake, find out from a field guide (some are listed at the bottom of this page) what kind of food the snake usually eats before you try to feed it. The hog-nosed snake or puff-adder usually feeds only on toads. The common garter snake usually eats such food as earthworms, small frogs, salamanders, tadpoles, and small fish. Sometimes a pet garter snake will even eat bits of raw chopped meat (*unseasoned*) when this food is moved slowly in front of its head, or better, mixed with earthworms.

If you take good care of your snake, it will thrive and you can learn a lot about the ways of snakes. If you have trouble finding food for your pet, however, take it back to the place where you found it and let it go ■

■ Look in a library or bookstore for these guides to identifying snakes: **Field Book of Snakes,** by K. P. Schmidt and D. D. Davis, G. P. Putnam's Sons, New York, revised 1964, $3.95; **A Field Guide to Reptiles and Amphibians** (Eastern North America), by Roger Conant, 1958, and **A Field Guide to Western Reptiles and Amphibians,** by Robert C. Stebbins, 1966, Houghton Mifflin Co., Boston, each $4.95; **Reptiles and Amphibians,** by Herbert Zim and Hobart Smith, Golden Press, New York, 1956, $1 (paper).

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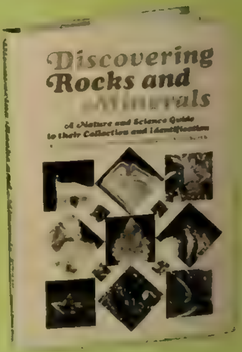
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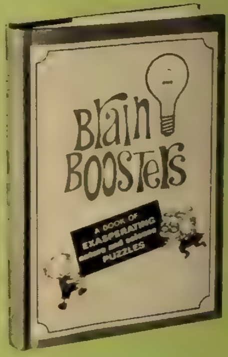
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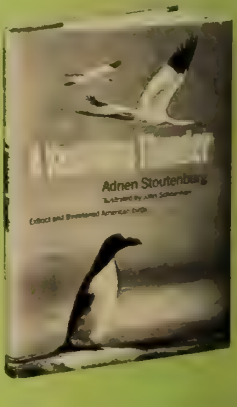
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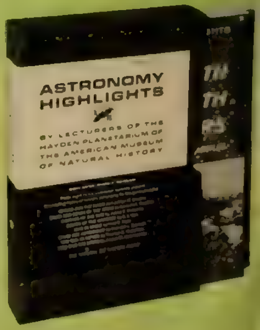
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